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A COMPUTER CODE (RVRDOS) TO CALCULATE POPULATION DOSES FROM RADIOACTIVE LIQUID EFFLUENTS AND AN APPLICATION TO NUCLEAR POWER REACTORS ON THE MISSISSIPPI RIVER BASIN

Office of Radiation Programs, Washington, D. C.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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OCTOBER 1976

U.S. ENVIRONMENTAL PROTECTION AGENCY
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ABSTRACT

A computer program RVRDOS has been developed to calculate population doses due to releases of radionuclides into flowing streams. Concentrations of the radionuclides downstream take into account dilution, decay, and the ingrowth of a daughter product. Population doses to four organs are calculated for drinking water and fish ingestion pathways. Individual doses due to swimming may also be estimated. A program manual for RVRDOS is included in this report.

RVRDOS has been used to calculate population doses due to releases from nuclear power reactors on the Mississippi River Basin during 1973. The data base for these calculations and a summary of the calculations are discussed.

PREFACE

The Office of Radiation Programs is concerned with the evaluation of radiation exposure to the population and the environment. Nuclear facilities may release radioactive materials to the environment from normal operations and thus become a potential source of exposure to the population. The Environmental Analysis Division has responsibilities for evaluating the environmental and public health impact from such releases.

The river dose model discussed in this report was developed to assess the consequences to the general population from the consumption of drinking water and fish from waters which receive radioactive liquid effluents. This is the first step by this Office to introduce a computer code as a working model to investigate the consequences of liquid radioactive discharges into rivers and streams. This model was applied to nuclear power plants on the Mississippi River System and population dose estimates were made which represent order of magnitude calculations. Although these results have not been validated by field measurements, the model and the results are of sufficient interest to warrant this interim report.

Readers are encouraged to write to this Office concerning suggestions, recommendations, and omissions or errors in this report.

Floyd L. Galpin

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Director
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CONTENTS

Abstract ii

Preface iii

I Introduction 3

II Summary and Results 7

III Aquatic Dispersion Model 15

IV RVRDOS Program Manual 25

Glossary 35

V References 41

VI Computer Printouts for RVRDOS Model 43

Tables

1. Radionuclides released in liquid effluents from selected nuclear power plants, Mississippi River Basin, 1973 8

2. Energy produced by selected nuclear power plants, Mississippi River Basin, 1973 9

3. Calculated total population dose commitments for selected nuclear power plants and pathways, Mississippi River Basin, 1973 10

4. Calculated total body population dose commitments (drinking water pathway) at selected locations downstream from nuclear power plants, Mississippi River Basin, 1973 11

Tables (continued)

5. Calculated total population dose commitments for selected pathways from nuclear power plants, Mississippi River Basin, 1973 12

6. Format for input data to RVRDOS 32

Figures

1. Nuclear power reactors on the Mississippi river basin, 1973 6

2. Schematic representation of a reach and definition of symbols used in Section III 21

I

INTRODUCTION

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I

INTRODUCTION

Under the concept of environmental dose commitment as applied by the Environmental Protection Agency (EPA), doses to all affected populations must be considered in the assessment of the overall risks vs. benefits of nuclear power industry operations (1). The measurement of dose on such a grand scale is normally very difficult because instruments of the required sensitivity are not available, or the extensive monitoring capabilities that would be required are too expensive to be cost effective, or both. EPA therefore suggests that in many cases the use of calculational techniques for dose assessment may be a cost-effective substitute to direct measurement (2). This appears to be the case for the assessment of population dose from the release of radioactive materials into flowing streams where the populations affected may be quite large and diverse and the pollutant concentrations quite small.

A model has been developed that can be used to calculate the dispersion of radioactivity released into flowing streams and the resulting population dose. A computer code called RVRDOS was developed for application of the model. The model has been applied to calculate the dose to affected populations from the release of radioactive materials during 1973 into the Illinois, Missouri, and the Mississippi Rivers by operating nuclear power plants.

The scope of this initial work was bounded by several factors. Individual doses and population doses within fifty miles of nuclear power plants are routinely analyzed in environmental reports, and there was no interest in duplicating these data. Doses to populations beyond fifty miles of operating facilities are not routinely estimated and such an estimate did appear to be desirable in the light of the dose commitment concept. It was shortly recognized that two major pathway parameters, sedimentation and resuspension of insoluble effluents, could not be considered adequately within the time frame and funding of this initial work. Although some rudimentary models are available, the required data base for over 1500 river miles does not exist and the development of such a data base represents an extraordinary task. For the drinking water pathway this difficulty was resolved by ignoring sedimentation and using dose factors for soluble forms of the effluent radionuclides, thereby obtaining a generally conservative (high) estimate of dose. For the fish consumption pathway, sedimentation and resuspension were treated implicitly via the use of measured reconcentration factors that relate the concentration of elements in fish to the concentration in water. These reconcentration factors include the effects of sedimentation and resuspension.

After performing a brief survey of river systems in the United States on which nuclear power reactors are located, the Mississippi River system was selected for study because of the larger number of operating reactors located on its waters and the large population using these waters. As the data base for the calculations was developed and after making a few preliminary calculations, it became clear that the drinking water and fish consumption pathways dominated the population dose and that other pathways, such as immersion (swimming), were trivial by comparison. Consideration was given to direct doses due to shoreline deposits, but this too was found to be a small contributor to population dose, although from an individual dose standpoint, it could be important close to an effluent point. As a result of these and a variety of other factors, the scope of this study was limited to the calculation of population doses via the ingestion pathway, using generally conservative assumptions.

It is stressed at the outset that the results of these calculations are to be considered as order of magnitude, yet generally conservative, results only, even though several significant figures are presented at places in this report. Further development of the model and more accurate or representative demographic and pathway data are expected to change the results. Nonetheless, the present model and especially the data base were considered to be of enough general interest that this initial report of the approach and the results was prepared.

II

SUMMARY AND RESULTS

Figure 1 Nuclear power reactors on the Mississippi river basin, 1973

II

SUMMARY AND RESULTS

J. A. Martin, Jr.,[1] and C. Robbins

The geographical extent of the anlysis performed to date is represented graphically in figure 1. Radionuclide activities released in 1973 into the Illinois River by the Dresden 2 and 3 units[2], into the Missouri River by the Ft. Calhoun unit, and into the upper reaches of the Mississippi by the Genoa and Quad Cities units were propagated from the points of release to the Gulf of Mexico. Doses to populations downstream of these units were calculated for the drinking water and fish ingestion pathways. Doses to four organs (whole body, thyroid, GI (LLI), and bone) were calculated using dose factors derived from data for the ICRP standard man (3,4).

Population drinking water statistics were taken directly from data compiled by the U. S. Public Health Service (5). The weight of commercial fish taken from locations along the rivers was obtained from data compiled by the U. S. Department of Commerce (6). Data for sport (creel) fish catches were obtained from State agency creel surveys and generally are not as complete as commercial fishing data. In view of the greater uncertainty, the sport catch data were treated separately from the commercial catch data. The creel catch data listed in the computer printouts in Section VI are a best effort compilation by the authors. Radionuclide reconcentration factors for fish were taken from reference 7.

Volume flow rates, stream speeds, river miles and volumes of dams required for the diffusion calculations were obtained from the U. S. Army Corps of Engineers' data (8-11) and water resources data published for various States by the U. S. Department of Interior Geological Survey. Stream speeds, river miles and volumes of dams were required for radioactive decay and daughter product ingrowth calculations. River miles were obtained directly from the river charts. Stream speeds were chosen by the authors as representative of data reported as estimates by a number of sources. Volumes of dams were calculated using river chart data and generally represent the volume of water in a given reach. Since all of the dams are small, increases in volume flow rates accounted for most of the dilution in the diffusion calculations.

All of these data are included in the printouts of the computer program RVRDOS in Section VI of this report. Representative data are briefly summarized in tables 1 to 5. Table 1 lists the source terms (activities of radionuclides released, by radionuclide) used for the calculations (12). The quantities and mixes of nuclides in effluents

---

[1] Present address: U.S. Nuclear Regulary Commission, Wash., DC, 20555.

[2] Only gross activity released was available for the Dresden 1 unit for the year 1973; dose calculations were thereby precluded.

Table 1 Radionuclides released in liquid effluents from selected nuclear power plants, Mississippi River Basin, 1973 (Curies)

Radionuclide	Genoa (LaCrosse)	Quad Cities 1 & 2	Dresden 2 & 3	Ft. Calhoun
^{140}BaLa	0.07	0.0071	1.48	0.0607
^{58}Co	11.8	0.97	0.144	0.469 (-4)
^{60}Co	1.26	0.83	2.09	.
^{51}Cr	0.81	2.88	1.17	.
^{134}Cs	5.66	0.21	1.17	.
^{137}Cs	10.1	0.53	4.24	.
^{137m}Ba	.	.	.	.
^{3}H	103.0	24.5	25.8	15.8
^{131}I	3.13	3.8	1.41	0.0045
^{131m}Xe	.	.	.	.
^{133}I	2.89	0.43	.	.
^{133}Xe	0.43	.	.	0.058
^{54}Mn	0.085	0.37	0.406	0.219
^{89}Sr	0.05	0.064	0.089	0.116 (-3)
^{89m}Y	.	.	.	0.169 (-4)
^{90}Sr	0.021	0.0025	0.01	.
^{90}Y	.	.	.	.
^{135}Xe	0.18	0.085	.	.
^{135}Cs	.	.	.	.
^{65}Zn	0.216	.	0.037	.
^{95}Zr	.	0.1116	0.009	.
^{95}Nb	.	.	0.007	.

Notes: . = Not reported.
(-N) = 10^{-N}

from different facilities are unrelated to one another and are dependent upon operating history, type of fuel and particular effluent treatment systems used by the various units. Although not used for the population dose calculations, the unit operating data for 1973, shown in table 2, may be of interest from a risk/benefit standpoint.

No activity was released in liquid effluents by Monticello. The 0.016 microcuries mixed fission and activation products and 73 microcuries tritium released in liquid effluents by Prairie Island are considered negligible for these dose calculations.

The activity released in liquids from Dresden 1 is not included because specific radionuclide data are not available. The mixed fission and activation product activity released by this facility in 1973 was 9.2 curies and the tritium activity released in liquid effluents was 18.5 curies.

Table 2 Energy produced by selected nuclear power plants, Mississippi River Basin, 1973

	Authorized Power Level (Megawatts (th))	Electrical Energy Produced (Megawatt-years)
Genoa (LaCrosse)	165	22
Quad Cities-1	2511	547
-2	2511	580
Dresden-1	700	625
-2	2527	558
-3	2527	413
Ft. Calhoun	1420	67
Monticello	1670	368
Prairie Island-1	1650	2
Total energy produced		3182

The results of the calculations are briefly summarized in tables 3, 4, and 5. (Details may be obtained from a perusal of the computer printouts. The RVRDOS code includes an option to print even finer detail, but the bulk prohibits its reproduction in this report.) The dose conversion factors (DCF) used for these calculations are for the first year dose due to an ingestion of the radionuclide. They are equivalent to dose commitment conversion factors with the exception of strontium-90 which has a long biological half-life. Strontium-90, however, contributes so little to the total organ doses from all nuclides released that the first year doses are equivalent to dose commitments and are so indicated in tables 3, 4, and 5.

Table 3 Calculated total population dose commitments for selected nuclear power plants and pathways, Mississippi River Basin, 1973

Facility		Person-rem			
		Total Body	Thyroid	Bone	GI(LLI)
Genoa (LaCrosse)	Drinking Water	10.5	7.	8.7	2.2
	Comm'l Fish	9.8	0.9	8.2	0.4
	Creel Fish	0.7	0.05	0.6	0.03
Quad Cities	Drinking Water	0.63	32.	0.65	0.6
	Comm'l Fish	0.14	0.45	0.12	0.17
	Creel Fish	0.01	0.02	0.006	0.01
Dresden 2,3	Drinking Water	1.5	2.3	1.5	0.45
	Comm'l Fish	0.15	0.02	0.14	0.01
	Creel Fish	0.002	0.0005	0.002	0.0001
Ft. Calhoun	Drinking Water	0.07	0.25	0.009	0.14
	Comm'l Fish	7(-6)	3(-5)	2(-7)	1(-4)
	Creel Fish	2(-6)	1(-5)	5(-7)	3(-5)

Note: $(-N) = 10^{-N}$

Table 4 Calculated total body population dose commitments (drinking water pathway) at selected locations downstream from nuclear power plants, Mississippi River Basin, 1973

Location	Population Served (Thousand)[a]	River Miles[b]	Total body population dose commitment (person-rem)				
			Genoa (LaCrosse)	Quad Cities	Dresden 2,3	Ft. Calhoun	Subtotal
LaCrosse, WI		1633					
Cordova, IL		1460					
Bettendorf, IA--Moline, IL	55.6	1442	1.0	0.065			1.07
Davenport, IA--Rock Island, IL	142.0	1439	2.6	0.16			2.76
Burlington, IA	35.4	1360	0.57	0.034			0.60
Ft. Madison, IA	15.2	1338	0.24	0.014			0.25
Keokuk, IA	16.3	1320	0.25	0.014			0.26
Quincy, IL	47.5	1283	0.63	0.037			0.67
Hannibal, MO	21.0	1265	0.26	0.015			0.28
Lock & Dam 27	40.0	1141	0.24	0.013			0.25
St. Louis, MO--East St. Louis, IL	670.0	1136	3.5	0.2	1.1	0.007	4.80
Chester, IL	4.2	1065	0.02	0.001	0.007	4.0 (-5)[c]	0.03
Cape Girardeau, MO	26.0	1008	0.13	0.007	0.042	2.0 (-4)	0.18
Thebes, IL	0.5	1000	0.002	0.0001	0.0007	4.0 (-6)	0.003
Vicksburg, MS	41.0	438	0.066	0.004	0.021	1.0 (-4)	0.091
Donaldsville, LA	7.8	177	0.012	0.007	0.004	2.0 (-5)	0.023
New Orleans, LA	652.0	100	1.0	0.056	0.034	0.002	1.09
Totals	1,774.0	-	10.5	0.63	1.5	0.009[d]	12.7[d]

[a] Population actually served drinking water from Mississippi River.

[b] River miles to Head of Passes, LA.

[c] $(-N) = 10^{-N}$

[d] Population dose on Missouri River was calculated as 0.058 person-rem.

The main results are presented in table 3 which lists the calculated total population doses due to the discharges listed in table 1. The doses are broken down by facility, organ and pathway, summed over location. To illustrate the detail considered to date in the analysis, a breakdown of the total body population dose due to drinking water consumption, by source and location, is presented in table 4. In 1973, discharges of radionuclides into the Illinois, Missouri, and Mississippi Rivers as by-products of the production of 2557 megawatt years of electrical energy resulted in a total body population dose of approximately 13 person-rem in a population of 1,774,000 persons consuming drinking water from those streams.

As illustrated in table 5, including drinking water and fish consumption pathways, the calculated total population doses in 1973 for the total body, thyroid, bone and GI(LLI) organs were 24, 43, 20 and 4 person-rem, respectively.

Table 5 Calculated total population dose commitments for selected pathways from nuclear power plants, Mississippi River Basin, 1973

Pathway (Population or catch weight)	Person-rem			
	Total body	Thyroid	Bone	GI (LLI)
Drinking water (1,774,500 persons)	12.7	41.6	10.8	3.4
Commercial fish (11,280,000 lbs.)	10.1	1.4	8.5	0.6
Creel fish (385,000 lbs.)	0.7	0.1	0.6	0.04
Total	24.	43.	20.	4.

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III

AQUATIC DISPERSON MODEL

C. B. Nelson

Introduction

The aquatic disperson model used in the RVRDOS code considers dilution, decay, and the ingrowth of a daughter product. Diffusion is not considered; the concentration is considered uniform across a stream. The variations in quantities with downstream distance from the source are treated by dividing the modeled stream into a number of segments or reaches as shown in figure 2. Reach boundaries are chosen so that concentrations calculated for the downstream end of the reach adequately characterize the concentrations within the reach. The stream flow rate is not allowed to decrease in the downstream direction and no explicit provision for branching of the stream is provided. Each reach may incorporate an impoundment such as would occur behind a dam on the stream. Such an impoundment is assumed to be uniformly mixed. The only removal process considered in the model is radioactive decay. To simplify notation, the equations in this section are developed for $i = 1$ (see figure 2) and the nuclide subscript is used only as necessary to distinguish a parent and daughter.

Dilution

Ignoring decay the activity flow (Ci/s) is conserved for the length of the reach, i.e.,

$$C_o W_o = C_1 W_1$$

or solving for C_1

$$C_1 = \frac{C_o W_o}{W_1}$$

Decay

Neglecting for the moment the effect of an impoundment, the decay factor for a reach is $\exp(-\lambda t_1)$ where λ is the decay constant for the particular radionuclide and $t_1 = d_1/V_1$ is the transit time for the reach.

Including the decay factor, then:

$$C_1 = \frac{C_o W_o}{W_1} \exp(-\lambda t_1)$$

Ingrowth of a Daughter

If λ_p and λ_d are the decay constants for the parent and daughter radionuclides and once again the effect of an impoundment is neglected, then:

$$C_{1p} = \frac{C_{op}W_o}{W_1} \exp(-\lambda_p t_1) \qquad \ldots(1)$$

and

$$C_{1d} = \frac{C_{od}W_o}{W_1} \exp(-\lambda_d t_1) \qquad \ldots(2)$$

$$+ \frac{C_{op}W_o}{W_1} \frac{\lambda_d}{\lambda_{d-}\lambda_p} (\exp(-\lambda_p t_1)-\exp(-\lambda_d t_1))$$

where the decay of the parent branches totally to the ingrowth of the daughter (Provision is made in the RVRDOS code for the actual branching ratio.). Note that the concentration of the daughter at the end of a reach depends upon its initial concentration at the start of the reach as well as the ingrowth from the parent during the course of the reach.

Effect of an Impoundment

To simplify the calculations for a reach with an impoundment, consider initially the case of a reach consisting only of the impoundment, i.e.,

$$d_1 = 0.$$

The impoundment is considered to be uniformly mixed. Quantities with the subscript 0 are those prior to the impoundment and those with the subscript 1 pertain to the impoundment and its outflow. The impoundment is considered to have a turnover rate given by:

$$\lambda_t = W_1/V_1$$

which implies that the impoundment may be fed by additional sources.

The concentrations in the impoundment are obtained from the following differential equations:

$$\frac{dC_{1p}}{dt} = -\lambda_a C_{1p} + \frac{W_o}{V_1} C_{op}$$

and

$$\frac{dC_{1d}}{dt} = \lambda_d C_{1p} - \lambda_b C_{1d} + \frac{W_o}{V_1} C_{od}$$

where $\lambda_a = \lambda_p + \lambda_t$ and $\lambda_b = \lambda_d + \lambda_t$. $\frac{W_o}{V_1} C_{op}$ and $\frac{W_o}{V_1} C_{od}$ are the forcing functions for the system. If C_{op} and C_{od} are set to 0,

the resulting homogeneous equations may be solved using standard methods (see reference 13) to obtain the response of the system to a unit concentration of

$$C_{1p} \text{ at } t = 0.$$

Designating these impulse response solutions as h_{+pp} and h_{+dp}:

$$h_{+pp}(t) = \exp(-\lambda_a t)$$

$$h_{+dp}(t) = \frac{\lambda_d}{\lambda_d - \lambda_p} (\exp(-\lambda_a t) - \exp(-\lambda_b t))$$

where h_{+pp} and h_{+dp} refer to the parent and daughter concentrations in the impoundment, respectively, due to the unit initial concentration of the parent.

Similarly for a unit inital concentration of C_{1d}

$$h_{+pd}(t) = 0$$

and

$$h_{+dd}(t) = \exp(-\lambda_b t)$$

Since the contribution of an initial daughter concentration is only to the daughter, it can be calculated separately and added to the contribution from the parent; the next step of this development will consider the initial daughter concentration to be zero.

The particular solution to the differential equations is obtained by convolution of the forcing function with the impulse response of the system. Since $C_{op}(\tau)$ is constant for $o<\tau<t$, its value can be taken outside the integral sign. Hence,

$$C_{1p}(t) = \int_o^t h_{+pp}(t-\tau)\, C_{op}(\tau)\, \frac{W_o}{V_1}\, d\tau$$

$$= \frac{W_o}{V_1} C_{op} \int_o^t \exp(-\lambda_a (t-\tau))d\tau$$

$$= \frac{W_o}{V_1} C_{op} \frac{1-\exp(-\lambda_a t)}{\lambda_a}$$

and

$$C_{1d}(t) = \int_o^t h_{+dp}(t-\tau)\, C_{op}(\tau)\, \frac{W_o}{V_1}\, d\tau$$

$$= \frac{W_o}{V_1} C_{op} \frac{\lambda_d}{\lambda_d-\lambda_p} \int_o^t (\exp(-\lambda_a (t-\tau))$$

$$-\exp(-\lambda_b(t-\tau)))d\tau$$

$$= \frac{W_o}{V_1} C_{op} \frac{\lambda_d}{\lambda_d - \lambda_p} \frac{\lambda_d - \lambda_p - \lambda_b \exp(-\lambda_a t) + \lambda_a \exp(-\lambda_b t)}{\lambda_a \lambda_b}$$

At equilibrium (i.e., $\lambda_a t >> 1$ and $\lambda_b t >> 1$)

$$C_{1p} = \frac{W_o}{V_1 \lambda_a} C_{op}$$

$$C_{1d} = \frac{W_o}{V_1 \lambda_a} \frac{\lambda_d}{\lambda_b} C_{op}$$

$$= \frac{\lambda_d}{\lambda_b} C_{1p}$$

Alternatively in terms of λ_p and λ_d:

$$C_{1p} = \frac{W_o}{W_1 + V_1 \lambda_p} C_{op} \qquad \ldots(3)$$

$$C_{1d} = \frac{V_1 \lambda_d}{W_1 + V_1 \lambda_d} C_{1p} \qquad \ldots(4)$$

Since the turnover time for an impoundment is short compared to the typical time period for a RVRDOS calculation, equilibrium is assumed for such calculations even for long lived radionuclides.

Returning now to a reach with a finite length, the concentration of the parent radionuclide can be calculated by combining (3) with the decay factor from (1) giving

$$C_{1p} = \frac{W_o}{W_1 + V_1 \lambda_p} \exp(-\lambda_p t_1) C_{op} \qquad \ldots(5)$$

Similarly the daughter ingrowth for a stream with an impoundment can be calculated as:

$$C_{1d} = \left(\frac{W_o}{W_1+V_1\lambda_d} \frac{\lambda_d}{\lambda_d-\lambda_p} (\exp(-\lambda_p t_1)-\exp(-\lambda_d t_1))\right.$$

$$\left. + \frac{W_o}{W_1+V_1\lambda_p} \frac{V_1\lambda_d}{W_1+V_1\lambda_d}\right) C_{op}$$

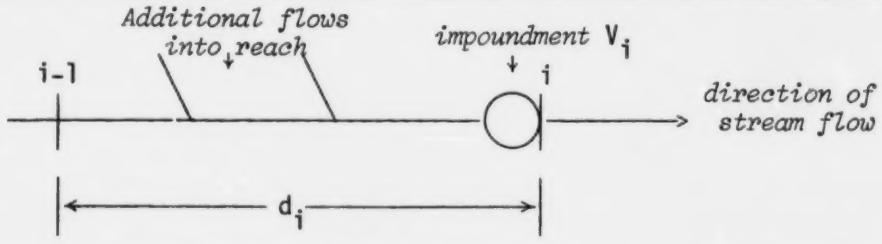
or

$$C_{1d} = \frac{W_o}{W_1+V_1\lambda_d} \frac{\lambda_d}{\lambda_d-\lambda_p} (\exp(-\lambda_p t_1)-\exp(-\lambda_d t_1)) C_{op}$$

$$+ \frac{V_1\lambda_d}{W_1+V_1\lambda_d} C_{1p} \qquad \ldots(6)$$

Calculations for RVRDOS are based on (5) and (6).(Note that in the RVRDOS code the location corresponding to I=1 is the release point to the stream and I=2 corresponds to the first downstream location.). First the concentration for a specific nuclide is calculated using (5). Then, if the nuclide is a daughter, the ingrowth from its parent is calculated using (6) and added to the original calculation. Calculations proceed from reach to reach in the downstream direction. The concentrations calculated for the end of one reach are used as those for the input to the subsequent one. Note that the variables actually used in RVRDOS have various customary units and that conversion factors are employed as necessary to make them consistent. These conversions have been avoided for this discussion by assigning a consistent set of units to the variables.

Figure 2 Schematic representation of a reach and definition of symbols used in Section III.



W_i = Volume flow rate of the stream at location i (m^3/s)

u_i = Speed of the stream at location i (m/s)

C_{ij} = Concentration of nuclide j at location i (Ci/m^3)

d_i = Distance between location i and i-1 associated with the i^{th} reach (m)

V_i = Volume of an impoundment on the i^{th} reach (m^3)

Note that the values of the variable for the i^{th} reach are assumed to be those for the end of the reach. The following quantities are calculated from the above.

t_i = The transit time associated with reach i (s)

λ_{ti} = The turnover rate for the impoundment on reach i (s^{-1})

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IV

RVRDOS PROGRAM MANUAL

A FORTRAN IV PROGRAM TO CALCULATE POPULATION AND INDIVIDUAL DOSES DUE TO THE DISCHARGE OF RADIONUCLIDES INTO FLOWING STREAMS

James A. Martin Jr.
Robert D. Cousins Jr.

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Introduction

RVRDOS is an attempt to fill the need for a simple self-inclusive code which, with a minimum of input data, can provide useful estimates of ingestion and immersion doses to individuals or populations served by streams into which radionuclides are released. The user must input data concerning 1) the radioactive releases at the discharge point, and 2) the principal downstream locations (including dams). Principal downstream locations will primarily be those locations where water or fish are taken from the river to be used for human consumption. Branching of a stream is not included.

The essential data required to run RVRDOS are: activity released (by radionuclide, including first daughter product information); dilution volumes; stream speed and volume flow rates at each location; river miles at the locations; volumes of dams on the stream; and the amounts (pounds) of fresh water fish (commercial and sport) taken from the stream at various locations. As many as thirty-five downstream locations and twenty radionuclides may be included. Ingestion dose conversion factors (DCFS) for one to four body organs (by radionuclide) and immersion DCFs for one or two organs must also be included with the input data.

The output consists of a summary of the input data, followed by:

1) Radionuclide concentrations at each of the locations.

2) Drinking water population dose rates for each body organ from each radionuclide at each location, and individual swimming dose rates. (The latter do not appear in the population dose rate tables, or in the summaries.)

3) and 4) Commercial and creel fish ingestion population dose rates to each organ from each nuclide at each location.

5) A summary of the entire run consisting of subtotals of the above doses:

a) summed over all locations listed, by radionuclide and critical organ,

b) summed over all radionuclides listed, by location and critical organ,

c) totaled over all locations and radionuclides, by critical organ.

If the user desires to calculate dose rates to an individual, it is only necessary to input a population of 1 and the appropriate amount of fish caught (See section on Input Data).

In order to be able to run RVRDOS, the user need only read this introduction and the section entitled "Input Data." Further information on the calculations used and on the code itself is contained in the section entitled "Calculations."

Input Data

The precise format for input data may be found in table 6. The following paragraphs contain supplemental information and clarification when necessary.

The first two cards contain information covering the entire run. Next follows a pair of cards for each location on the stream for which dose calculations are to be performed. Location #1 should be the discharge canal, and the volume flow rate for location #1 should be the discharge canal flow rate (ft^3/sec). Location #2 should be downstream from the facility. (The model used for calculations is not applicable to the river at the discharge point, since mixing is not at all complete at this point.) The rest of the locations should be in order of increasing distance downstream. The following conversion factors may be useful:

1 gallon/minute = $2.23 \times 10^{-3} ft^3$/sec
1 liter/year = 1.119×10^{-9} ft^3/sec

The river miles may be measured from any fixed point (the facility need not have river mile zero), and may either increase or decrease with increasing distance downstream as long as the user is consistent. (The program uses the absolute values of the changes in river miles.) If there is no dam at a location the dam volume is input as Ø. Volumes (i.e., the volume of water behind dams) are in acre-feet:

1 acre-foot = 43,560 ft^3 = .326 million gallons

The pounds of fish taken from the stream between locations N-1 and N are input with the data for location N (the section of the river between any location N and location N-1 is called a reach). Fish data is divided into two categories: that caught commercially and that caught by sports fishermen (so-called creel catch). To calculate an individual ingestion dose rate for a reference man eating 26 gm/day (landed weight), input should be 21 pounds per year creel catch. (It should be recognized that the populations consuming fish and water are quite different.)

When computing population doses due to drinking water, the population which derives its drinking water from the river within the reach is input.

Reaches should be selected such that radionuclide decay between the location of a drinking water system intake and the end of the reach, N, is small. Concentrations used for calculating drinking water doses are the concentrations at point N. If the dose to an individual is desired at location N, then a population of 1 is input.

After the location data cards, two cards follow with the number of radionuclides in the run, and the names of the critical organs for which doses are to be calculated.

Finally, there are three cards for each radionuclide. These contain decay data, dose conversion factor (in the same order as the names appearing on the earlier card), and release data (curies per year). The triplet for a daughter product must immediately follow the triplet for its parent nuclide.

Calculations

The initial concentration (location 1) for each nuclide is simply:

$$CONC_{1,\ell} = \frac{Q\ell}{FLOW_1} \cdot 1.12 \times 10^{-6}$$

where:

$CONC_{1,\ell}$ concentration of radionuclide ℓ in the discharge canal (micro-Ci/ml)

ℓ radionuclide index

$Q\ell$ activity release of nuclide ℓ,(Curies/year into discharge canal)

$FLOW_1$ discharge canal flow rate (ft^3/sec)

1.12×10^{-6} converts Ci/yr per ft^3/sec to micro-Ci/ml

Concentration of parent nuclides at downstream locations are calculated using the equation derived in Section III where:

VOL_n volume of water behind dam, between points N-1 and N (ft^3). If there is no dam, $VOL_n = \emptyset$.

$RLMDA_\ell$ radionuclide decay constant (1/sec)

DELAY transit time from N-1 to N, derived from the river mile distance and stream speed (If stream speed is entered as zero, a default value of 3 mph is assigned.).

Account must be taken of the fact that a parent nuclide may decay into more than one daughter. For instance, iodine-131 decays into xenon-131m in only 1% of its decays. In the code, the calculated daughter concentration is multiplied by ($BRANCH_2$/100), where $BRANCH_2$ is the so-called branching ratio, the percentage of decays of p which yield d.

Water Ingestion Doses

Population doses due to water ingestion are calculated using the equation:

$$DPWTR_{n,\ell,m} = CONC_{n,\ell} \cdot DCF_{\ell,m} \cdot POP_n \cdot DRINKS. 365. 10^6$$

where:

n	location index
ℓ	radionuclide index
m	critical organ index (1, 2, 3, or 4)
DPWTR	population dose (person-rem/yr)
CONC	activity concentration, derived using equation (1) or (2) (micro-Ci/ml)
DCF	ingestion dose conversion factor (millirem per pico-Curie intake)
POP	is the population served by drinking water from the stream at n
DRINKS	is the assumed ingestion rate (liters/day per person)
365	days per year
10^6	pCi per micro-Ci

DRINKS is set equal to 1.95 in the code. It may be easily changed, but the program must then be recompiled.

RVRDOS does not take into account depletion by ingestion or depletion by water and sewage treatment plants. Since a very small fraction of a stream is used for drinking water, depletion by ingestion may be ignored. Although water treatment plants, industrial uses and sewage treatment plants may have large decontamination factors for the water taken from the stream, only a small fraction of a stream is used by any given

municipality. By ignoring these decontamination factors, RVRDOS provides a conservative estimate of population dose. Conservatism becomes greater and greater as distance from the source increases.

Swimming (Immersion) Doses (M = 5 and 6)

Individual doses at location n, to organ m, from nuclide ℓ, due to swimming in the stream are calculated using the equation:

$$\text{Dose in rem/yr} = CONC_{n,\ell} \cdot DCF_{\ell,m} \cdot HOURS \cdot 10^{6}$$

where:

n,ℓ,m location, nuclide, and organ indexes, respectively (m =5 or 6)

CONC activity concentration, micro-Ci/ml

DCF mrem/hr per pCi/liter (note different units from those of ingestion DCFs)

HOURS assumed time spent swimming (hours/year per person)

Swimming population doses are not calculated, only individual swimming doses.

The parameter HOURS is fixed in the code with the value of 100. Like DRINKS it may be easily changed but the program must be recompiled.

Fish Ingestion Doses

Population doses due to commercial fish ingestion are calculated using the relation:

$$DPCML_{n,\ell,m} = CONC_{n,\ell} \cdot RECONC_{\ell} \cdot DCF_{m,\ell} \cdot CTCHWT_{n,1} \cdot 0.4536 \times 10^{6} \cdot CATUSE \cdot CATEAT \cdot CTLELF$$

where:

DPCML the population dose (person-rem/year)

CONC the activity concentration (micro-Ci/ml)

RECONC the fresh water fish reconcentration factor, (ci/gm per Ci/ml)

DCF	dose conversion factor (mrem per pCi intake)
$CTCHWT_{n,1}$	the total commercial fish yield between points n-1 and n (pounds/year)
0.4536	(kilograms/pound)
10^6	pico-Ci/micro-Ci
CATUSE	the fraction of all commercially caught fish that is available for human consumption
CATEAT	the fraction (by weight) of a whole fish that is actually edible
CTLEFT	the fraction of nuclide in edible fish that remains after cooking, frying, etc.

The parameters CATUSE, CATEAT, and CTLEFT are set equal to 0.49, 0.45, and 0.80, respectively, based on available data. These values may be changed if the program is recompiled. Fresh water reconcentration factors for all elements up to atomic number ninety-five are also included in the code, and may be similarly changed by the user.

DPCRL, the dose rate due to creel fish ingestion, is calculated from the same equation with two changes:

1) $CTCHWT_{n,2}$ is used rather than $CTCHWT_{n,1}$

2) CATUSE is assumed to be 1, and is therefore omitted.

Sedimentation and resuspension processes are treated implicitly in the reconcentration factors; these factors are grand averages from many observations that have been made and include reconcentration by bottom feeders and other organisms that are eaten by fish.

No decay factor is included in the population dose equation; thus, the tacit assumption is made that the water and fish are consumed immediately and at a uniform rate throughout a year. The former is generally conservative depending upon the nuclide and organ, but this is a trivial perturbation in the light of other sources of error.

Depletion of a stream via fish catches is not treated in RVRDOS. This is another conservatism, but likely a trivial one in most cases

of interest. For radionuclides other than tritium, the tacit assumption that all radionuclides are soluble in the stream leads to generally conservative estimates of ingestion population doses.

Program Flow

The program flow is straightforward. In order, parameters are initialized; input data are read; concentrations are calculated; water and swimming doses are calculated and printed; commercial and creel fish doses are calculated and printed; and a summary of the run is tabulated and printed. The code includes comments describing the steps performed. The calculations will stop if the absolute value of the distance from location N-1 to location N decreases. Since this model is inapplicable for rivers that branch, the calculations will also stop if a volume flow rate (FLOW) at location N-1 exceeds the rate at N. Various checks to prevent inadvertent division by zero are also included. Several separate decks of cards of data may be processed in one run by merely stacking them one after another.

Data Base

A data base is included in Section VI. These data were compiled for the Illinois, Missouri, and Mississippi Rivers from Head of Passes near the mouth of the Mississippi, upstream to the locations of four nuclear power plants that discharged radionuclides into these rivers in 1973.

Table 6 Format for input data to RVRDOS

Card Sequence	Columns	Content	Format
1 Card	1-20	Facility name	5A4
	22-25	Year of data	A4
	29-30	Number of months of data	A2
	34-45	Source of release data	3A4
	70	Blank or 1. (Print command)	I1
1 Card	4-5	Number of locations on stream, including facility (discharge point) Maximum 35	I2
N pairs of Cards		One pair for each location on stream	
1st Card	4-5	Number of this location (Facility discharge canal is number 1)	I2
	6-25	Name of this location	5A4
2nd Card	1-10	Population deriving drinking* water from the river between location N and N-1.	F10.0
	11-20	Volume flow rate at this location in ft^3/sec. For location 1, this should be the discharge canal blowdown rate. (Computer will then calculate initial concentrations in discharge canal). For the rest of the locations the flow rate is that of the river.	F10.0

*Drinking water population doses are calculated for the entire population which derives its drinking water from the river between locations N and N-1. Reaches should be selected such that the decay between the intake to the supply and the end of the reach is small. Concentrations used to calculate the drinking water dose are those at location N. If the dose to one individual is desired at location N, input a population of 1.

Table 6 Format for input data to RVRDOS (continued)

Card Sequence	Columns	Content	Format
	21-30	Stream speed in mi/hr	F10.2
	31-40	River mile from some fixed reference point. (Facility need not have river mile Ø).	F10.2
	41-50	Volume of water behind dam at location N, in acre-feet. If there is no dam at location N, then this is Ø.	F10.0
	51-60	Pounds of fish caught commercially per year between points N-1 and N.	F10.0
	61-70	Pounds of creel fish caught per year	F10.0
1 Card	4-5	Number of radionuclides released (1 to 20)	I2
1 Card	1-8	Name of 1st critical organ (ingestion)	2A4
	9-16	Name of 2nd organ (ingestion)	2A4
	17-24	Name of 3rd organ (ingestion)	2A4
	25-32	Name of 4th organ (ingestion)	2A4
	33-40	Name of 5th organ (immersion)	2A4
	41-48	Name of 6th organ (immersion)	2A4
Sets of 3 cards		One set for each radionuclide	
1st Card	3-10	Symbol and mass number of nuclide, e.g., Co-58	2A4
	11	Daughter call code Ø for parent, 1 for daughter of immediately preceeding nuclide	I1

Table 6 Format for input data to RVRDOS (continued)

Card Sequence	Columns	Contents	Format
	12-15	Branching ratio: % of decays of preceeding nuclide yielding this nuclide (Ø if parent)	F4.0
	19-20	Atomic number	I2
	21-30	Decay constant, 1/sec	E10.3
2nd Card	1-40	Ingestion dose conversion factors for each of the four critical organs listed on earlier card, mrem per pCi intake	4E10.3
	41-60	Swimming (immersion) dose conversion factors for two organs in mrem/hr per pCi/ liter	2E10.3
3rd Card	1-10	Activity released at facility, Curies/yr	E10.3

GLOSSARY FOR RVRDOS

B, D, E, F, H, I, J, K, A1, A2, B1, B2, D1, D2, DECAYP, NMIN, DECAYS, S1, S2, S3--All are temporary variables of little significance.

ARG--Argument of exponential, equal to RLMDA times DECAY.

BRANCH(L)--Branching ratio (%): the percentage of decays of nuclide L-1 that result in nuclide L. Ø for parent.

CATEAT--Fraction (by weight) of a whole fish that is actually edible; set equal to 0.45.

CATUSE--Fraction of all commercially caught fish that is used for human consumption; set equal to 0.49.

CMLTOT(L,M)--DPCML(N,L,M), summed over N.

CONC(N,L)--Activity concentration in microcuries/milliliter.

CRLTOT(L,M)--DPCRL(N,L,M), summed over N.

CTCHWT(N,1)--Pounds of commercial fish taken from stream at N.

CTCHWT(N,2)--Pounds of creel fish taken from stream at N.

CTLEFT--Fraction of nuclide that remains in fish after cooking, frying, etc; set equal to 0.80.

DCF(M,L)--Dose conversion factors for organ M and nuclide L. For M = 1 - 4: ingestion DCFs in millirem per picocurie intake. For M = 5,6: swimming (immersion) DCFs, in mrem/hr per pcurie/liter.

DCMLNM(N,M)--DPCML(N,L,M), summed over L.

DCRLNM(N,M)--DPCRL(N,LMM), summed over L.

DELAY--|RIVM(N) - RIVM(N-1)| *3600/VEL(N). time in seconds required for river to flow from location N-1 to location N.

DLUTE--Flow (N-1)/(Flow (N) + VOL (N) *RLMDA (L)). Dilution factor for river between N-1 and N, for nuclide L.

DPCML(N,L,M), DPCRL(N,L,M),DPWTR(N,L,M)--Population dose rates for location N, nuclide L, and critical organ M (in person-rem per year), due to ingestion of drinking water (DPWTR), commercial fish (DPCML), and creel fish (DPCRL).

DPCML(M)--DCMLNM(N,M), summed over N.

DPCRLM(M)--DCRLNM(N,M), summed over N.

DPWTR(M)--DWTRNM(N,M), summed over N.

DRINKS--Assumed drinking water consumption rate. Set equal to 1.95 liters/day per person.

DWTRNM(N,M)--DPWTR(N,L,M), summed over L.

FAC1 to FAC5--Facility name, total 20 characters.

FLOW(N)--Volume flow rate at location N, cubic feet per second.

HOURS--Assumed time one person spends swimming in river; set equal to 100 hours per year.

L--Counter for radionuclides, 1-20.

LZ(L)--Atomic number of nuclide L.

M--Counter for locations 1-35. Release point has N=1.

NDTR(L)--Daughter call code=Ø, if parent; 1, if daughter. Data for daughter product must immediately follow data for parent.

NISO--Number of radionuclides in run; maximum of 20.

NMN1(N) to NMN5(N)--Name of Nth location, up to 20 characters.

NMOGN1(M), NMOGN2(M)--Name of critical organ corresponding to DCF for M; up to eight characters

NMOS--Number of months of data, (used only for printing output). NMOS=12 is assumed in all calculations.

NNPC(N)--User-assigned number of location N. Normally NNPC(N)=N.

NPC--Number of locations in run, including release point.

NREF1, NREF2, NREF3--Reference for release data (e.g., EIS, AEC report), up to 12 characters.

NUCL1(L), NUCL2(L)--Name of radionuclide L (e.g., CO-58), up to eight characters.

POP(N)--Population deriving drinking water from the river at location N.

Q(L)--Total curies of radionuclide L released at location during year.

RECONC(LZ(L))--Fresh water fish reconcentration factors. (Included in program for LZ=1 to LZ=95.)

RIVM(N)--River mile at N, from any fixed reference point.

RLMDA(L)--Decay constant of nuclide L, 1/sec.

RMILES(N)--|RIVM(N)-RIVM(1)|: The distance of location N from the discharge point, in river miles.

TIME(N)--Travel time to location N, i.e., the total time available for ingrowth or decay between the release point and location N.

VEL(N)--Stream speed at N, in mi/hr. (Default = 3.0 mi/hr.)

VOL(N)--Volume of water behind dam between N-1 and N, in acre-feet.

WTRTOT(L,M)--DPWTR(N,L,M), summed over N.

V

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VI

COMPUTER PRINTOUTS FOR RVRDOS MODEL

Listing of source program for RVRDOS 45

Genoa:

- Input data 57
- Radionuclide concentrations by downstream location 60
- Drinking water doses by nuclide 63
- Drinking water doses by location 64
- Commercial fish ingestion doses by location 66
- Creel fish ingestion doses by location 68
- Travel time to downstream locations 71

Quad Cities:

- Input data 72
- Drinking water doses by location 74
- Commercial fish ingestion doses by location 75
- Creel fish ingestion doses by location 76

Dresden 2/3:

- Input data 77
- Drinking water doses by location 79
- Commercial fish ingestion doses by location 80
- Creel fish ingestion doses by location 81

Fort Calhoun:

- Input data 82
- Drinking water doses by location 84
- Commercial fish ingestion doses by location 85
- Creel fish ingestion doses by location 86

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FORTRAN IV G LEVEL  21                MAIN                DATE = 76173          17/22/03

                C                                                                          1.
                C                                  RVRDOS                                  2.
                C                                                                          3.
                C          A CODE FOR CALCULATING INGESTION POPULATION DOSE                4.
                C       RESULTING FROM DISCHARGES OF RADIONUCLIDES DIRECTLY INTO           5.
                C       A STREAM. THE DIFFUSION EQUATION USED IS A SIMPLE LONG             6.
                C       TERM AVERAGE MODEL BASED UPON VOLUME FLOW RATES, VOLUMES           7.
                C       OF DAMS AND RADIONUCLIDE DECAY CONSTANTS. POPULATION DOSES         8.
                C       DUE TO INGESTION OF STREAM WATER, AND COMMERCIAL AND               9.
                C       SPORT FISH CATCHES ARE CALCULATED AT UP TO THIRTY-FIVE            10.
                C       LOCATIONS ON THE STREAM. DOSES TO FOUR USER SELECTED              11.
                C       INTERNAL ORGANS, FROM UP TO TWENTY RADIONUCLIDES MAY BE           12.
                C       CALCULATED IN A SINGLE RUN. FRESH WATER FISH RECONCEN-             13.
                C       TRATION  FACTORS FOR NINETY-FIVE ELEMENTS ARE INCLUDED            14.
                C       IN THE CODE. INDIVIDUAL SKIN AND WHOLE BODY IMMERSION             15.
                C       DOSES MAY ALSO BE CALCULATED.                                     16.
                C                                                                         17.
                C                    JAMES A. MARTIN, JR.     10/74                       18.
                C                    ROBERT D. COUSINS        8/75                        19.
                C
0001                 DIMENSION NNPC(35),NMA1(35),NMN2(35),NMN3(35),NMN4(35),NMN5(35),  20.
               *       POP(35),FLOW(35),VEL(35),RIVM(35),DWTRNM(35,6),CTCHWT(35,2),     21.
               *       DPWTR(35,20,6),DPWTRM(6),RECONC(95),LZ(20),NUCL1(20),            22.
               *       NUCL2(20),RLMDA(20),DPCML(35,20,4),VOL(35),CONC(35,20),          23.
               *       DCF(6,20),Q(20),DPCRL(35,20,4),DPCRLM(4),DPCMLM(4),              24.
               *       DCRLNM(35,4),DCMLNM(35,4),NMOGN1(6),NMOGN2(6),NDTR(20),          25.
               *       BRANCH(20),RMILES(35),WTRTCT(20,6),CMLTOT(20,4),                 26.
               *       CRLTOT(20,4),TIME(35)                                            27.
0002                 DATA RECONC(1) / 0.9/                                             28.
0003                 DATA RECONC(2) / 1./                                              29.
0004                 DATA RECONC(3) / 0.5/                                             30.
0005                 DATA RECONC(4) / 2./                                              31.
0006                 DATA RECONC(5) / 0.2/                                             32.
0007                 DATA RECONC(6) / 5000./                                           33.
0008                 DATA RECONC(7) / 150CC./                                          34.
0009                 DATA RECONC(8) / 0.9/                                             35.
0010                 DATA RECONC(9) / 10./                                             36.
0011                 DATA RECONC(10) / 1./                                             37.
0012                 DATA RECONC(11) / 20./                                            38.
0013                 DATA RECONC(12) / 50./                                            39.
0014                 DATA RECONC(13) / 10./                                            40.
0015                 DATA RECONC(14) / 2.5/                                            41.
0016                 DATA RECONC(15) / 10CCC./                                         42.
0017                 DATA RECONC(16) / 750./                                           43.
0018                 DATA RECONC(17) / 50./                                            44.
0019                 DATA RECONC(18) / 1./                                             45.
0020                 DATA RECONC(19) / 1000./                                          46.
0021                 DATA RECONC(20) / 40./                                            47.
0022                 DATA RECONC(21) / 100./                                           48.
0023                 DATA RECONC(22) / 1000./                                          49.
0024                 DATA RECONC(23) / 10./                                            50.
0025                 DATA RECONC(24) / 40./                                            51.
0026                 DATA RECONC(25) / 10C./                                           52.
0027                 DATA RECONC(26) / 10C./                                           53.
0028                 DATA RECONC(27) / 20./                                            54.
0029                 DATA RECONC(28) / 10C./                                           55.
0030                 DATA RECONC(29) / 200./                                           56.
0031                 DATA RECONC(30) / 10CC./                                          57.
0032                 DATA RECONC(31) / 33C./                                           58.
```

Listing of source program for RVRDOS

```
FORTRAN IV G LEVEL  21                  MAIN                    DATE = 76226          12/23/13

0033                 DATA RECONC(32) / 3300./                                              59.
0034                 DATA RECONC(33) / 330./                                               60.
0035                 DATA RECONC(34) / 170./                                               61.
0036                 DATA RECONC(35) / 420./                                               62.
0037                 DATA RECONC(36) / 1./                                                 63.
0038                 DATA RECONC(37) / 2000./                                              64.
0039                 DATA RECONC(38) / 5./                                                 65.
0040                 DATA RECONC(39) / 25./                                                66.
0041                 DATA RECONC(40) / 3.3/                                                67.
0042                 DATA RECONC(41) / 30000./                                             68.
0043                 DATA RECONC(42) / 10./                                                69.
0044                 DATA RECONC(43) / 15./                                                70.
0045                 DATA RECONC(44) / 10./                                                71.
0046                 DATA RECONC(45) / 10./                                                72.
0047                 DATA RECONC(46) / 10./                                                73.
0048                 DATA RECONC(47) / 2.3/                                                74.
0049                 DATA RECONC(48) / 200./                                               75.
0050                 DATA RECONC(49) / 10000./                                             76.
0051                 DATA RECONC(50) / 3000./                                              77.
0052                 DATA RECONC(51) / 1./                                                 78.
0053                 DATA RECONC(52) / 500./                                               79.
0054                 DATA RECONC(53) / 15./                                                80.
0055                 DATA RECONC(54) / 1./                                                 81.
0056                 DATA RECONC(55) / 400./                                               82.
0057                 DATA RECONC(56) / 4./                                                 83.
0058                 DATA RECONC(57) / 25./                                                84.
0059                 DATA RECONC(58) / 25./                                                85.
0060                 DATA RECONC(59) / 25./                                                86.
0061                 DATA RECONC(60) / 25./                                                87.
0062                 DATA RECONC(61) / 25./                                                88.
0063                 DATA RECONC(62) / 25./                                                89.
0064                 DATA RECONC(63) / 25./                                                90.
0065                 DATA RECONC(64) / 25./                                                91.
0066                 DATA RECONC(65) / 25./                                                92.
0067                 DATA RECONC(66) / 25./                                                93.
0068                 DATA RECONC(67) / 25./                                                94.
0069                 DATA RECONC(68) / 25./                                                95.
0070                 DATA RECONC(69) / 25./                                                96.
0071                 DATA RECONC(70) / 25./                                                97.
0072                 DATA RECONC(71) / 25./                                                98.
0073                 DATA RECONC(72) / 3.3/                                                99.
0074                 DATA RECONC(73) / 30000./                                            100.
0075                 DATA RECONC(74) / 1200./                                             101.
0076                 DATA RECONC(75) / 120./                                              102.
0077                 DATA RECONC(76) / 10./                                               103.
0078                 DATA RECONC(77) / 10./                                               104.
0079                 DATA RECONC(78) / 100./                                              105.
0080                 DATA RECONC(79) / 33./                                               106.
0081                 DATA RECONC(80) / 1000./                                             107.
0082                 DATA RECONC(81) / 10000./                                            108.
0083                 DATA RECONC(82) / 300./                                              109.
0084                 DATA RECONC(83) / 15./                                               110.
0085                 DATA RECONC(84) / 50./                                               111.
0086                 DATA RECONC(85) / 15./                                               112.
0087                 DATA RECONC(86) / 57./                                               113.
0088                 DATA RECONC(87) / 400./                                              114.
0089                 DATA RECONC(88) / 50./                                               115.
0090                 DATA RECONC(89) / 25./                                               116.
```

Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                  MAIN              DATE = 76226          12/23/13

0091                DATA RECONC(90) / 30./                                              117.
0092                DATA RECONC(91) / 11./                                              118.
0093                DATA RECONC(92) / 10./                                              119.
0094                DATA RECONC(93) / 10./                                              120.
0095                DATA RECONC(94) / 3.5/                                              121.
0096                DATA RECONC(95) / 25./                                              122.
0097                WRITE(6,10)                                                         123.
0098              10 FORMAT(1HO,56X,'PROGRAM RVRDOS'//                                  124.
                   *43X,'FOR INFORMATION REGARDING THIS PROGRAM, CONTACT:'//,          125.
                   *51X,'ENVIRONMENTAL PROTECTION AGENCY'/                            126.
                   *51X,'OFFICE OF RADIATION PROGRAMS'/,                              127.
                   *51X,'401 M ST SW'/,                                               128.
                   *51X,'WASHINGTON, DC  20460'///,                                   129.
                   *61X,'INPUT DATA'/)                                                130.
                C                                                                     131.
0099              900 CONTINUE                                                        132.
                C                                                                     133.
                C     INITIALIZE VARIABLES                                          134.
                C                                                                     135.
0100                DO 20 L=1,20                                                      136.
0101                DO 20 N=1,35                                                      137.
0102                DPWTR(N,L,5) = 0.                                                 138.
0103                DPWTR(N,L,6) = 0.                                                 139.
0104                CONC(N,L) = 0.                                                    140.
0105                DO 20 M = 1,4                                                     141.
0106                DPWTR(N,L,M) = 0.                                                 142.
0107                DPCML(N,L,M) = 0.                                                 143.
0108             20 DPCRL(N,L,M) = 0.                                                 144.
0109                IF(CONC(1,1).GT.1.) GO TO 999                                     145.
0110                DO 25 N=1,35                                                      146.
0111                DWTRNM(N,5)=0.                                                    147.
0112                DWTRNM(N,6)=0.                                                    148.
0113                DO 25 M=1,4                                                       149.
0114                DWTRNM(N,M)=0.                                                    150.
0115                DCMLNM(N,M)=0.                                                    151.
0116             25 DCRLNM(N,M)=0.                                                    152.
                C                                                                     153.
                C     READ IN FACILITY DESCRIPTION AND DOWNSTREAM PARAMETERS          154.
                C     READ FACILITY NAME,YEAR, MONTHS, REFERENCES, PRINT COMMAND.     155.
                C     IF NPRINT=0, ONLY SUMMARY IS PRINTED. IF NPRINT=1, ALL DETAILS ARE 156.
                C     PRINTED. NPRINT IS IN COL 70 ON FIRST CARD.                     157.
                C                                                                     158.
0117                READ(5,100,END=999) FAC1,FAC2,FAC3,FAC4,FAC5,NYR,NMOS,NREF1,      159.
                   *                    NREF2,NREF3,NPRINT                            160.
0118              100 FORMAT(5A4,1X,A4,3X,A2,3X,3A4,24X,I1)                           161.
0119                WRITE(6,101) FAC1,FAC2,FAC3,FAC4,FAC5,NYR,NMOS,NREF1,NREF2,NREF3 162.
0120              101 FORMAT(1HO,6X,'FACILITY',7X,'YEAR OF RELEASES   NO. MONTHS OF ', 163.
                   *'DATA   SOURCE OF RELEASE DATA'/,1X,5A4,7X,A4,17X,A2,16X,3A4)     164.
                C                                                                     165.
                C     READ IN NUMBER OF LOCATIONS,INCLUDING FACILITY AS FIRST LOCATION 166.
                C      MAXIMUM OF 35 LOCATIONS.                                       167.
                C                                                                     168.
0121                READ(5,110) NPC                                                   169.
0122              110 FORMAT(3X,I2)                                                   170.
0123                WRITE(6,111) NPC                                                  171.
0124              111 FORMAT(1HO,11X,'LOCATIONS ON STREAM (TOTAL OF ',I2,', FACILITY ', 172.
                   *'IS NO. 1)')                                                      173.
                C                                                                     174.
```

Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                  MAIN                DATE = 76226          12/23/13

C     READ AND WRITE LOCATION DATA,INCLUDING FACILITY AS FIRST LOCATION.
C     VOLUME FLOW RATE FOR FACILITY IS AT POINT WHERE CURIES ARE
C     RELEASED.
C
      WRITE(6,116)
  116 FORMAT(1HO,'REACH',8X,'NAME',13X,'POPULATION  VOLUME FLOW    ',
     *'STREAM',5X,'RIVER  DAM VOLUME  COMMERCIAL  CREEL FISH'/' NUMBER',
     *26X,'SERVED     RATE(CFS)   SPEED(MPH)   MILE   ACRE-FEET   FISH '
     *,'WT,LBS   WT,LBS')
      A=0.
      B=0.
      C=0.
      DO 130 N=1,NPC
      READ(5,113) NNPC(N),NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N)
  113 FORMAT(3X,I2,5A4)
      READ(5,114) POP(N),FLOW(N),VEL(N),RIVM(N),VOL(N),CTCHWT(N,1),
     *CTCHWT(N,2)
  114 FORMAT(2F10.0,2F10.2,3F10.0)
      A=A+POP(N)
      B=B+CTCHWT(N,1)
      C=C+CTCHWT(N,2)
C
C      ASSIGN DEFAULT VALUE FOR VEL
C
      IF (VEL(N).LE.0) VEL(N)=3.
C
      WRITE(6,117) NNPC(N),NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),
     *POP(N),FLOW(N),VEL(N),RIVM(N),VOL(N),CTCHWT(N,1),CTCHWT(N,2)
  117 FORMAT(1HO,2X,I2,3X,5A4,1X,F10.0,3X,F10.0,2(1X,F10.1),1X,F10.0,2X,
     *F10.0,3X,F10.0)
C
C     VOL(N) IS IN ACRE FEET AS INPUT.
C     CONVERT UNITS TO CUBIC FEET.
C
      VOL(N) = VOL(N)*43560.
C
  130 CONTINUE
      TOTPOP=A
      TOTCML=B
      TOTCRL=C
C
C           READ/WRITE NUMBER OF ISOTOPES, MAX. OF 20.
C
      READ(5,200) NISO
  200 FORMAT(3X,I2)
      WRITE(6,210) NISO
  210 FORMAT(1HO,/,50X,'RADIONUCLIDES RELEASED (TOTAL ',I2,')')
C
C          READ AND WRITE ISOTOPE DATA
C
      READ(5,215) ((NMOGN1(M),NMOGN2(M)),M=1,6)
  215 FORMAT(12A4)
      WRITE(6,220) ((NMOGN1(M),NMOGN2(M)),M=1,6)
  220 FORMAT(1HO,85X,'DOSE CONVERSION FACTORS'/,82X,'INGESTION',27X,
     *'SWIMMING'/,' ISOTOPE  0=PARENT   BRANCH.  ATOMIC  DECAY CONS-',
     *'   CURIES',9X,'MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE      MREM'
     *,'/HR PER PCI/LITER'/,9X,'1=DAUGHTER  RATIO,%  NUMBER  TANT, 1/',
     *'SEC  RELEASED',4X,4(3X,2A4),2X,2(3X,2A4))
```

Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                MAIN                DATE = 75225          12/23/13

0154                  DO 240 L=1,NISO                                                    233.
0155                  READ(5,230) NUCL1(L),NUCL2(L),NDTR(L),BRANCH(L),LZ(L),RLMDA(L),    234.
                     *(DCF(M,L),M=1,6)                                                   235.
0156                230 FORMAT(2X,2A4,I1,F4.0,3X,I2,E10.3,/,6E10.3)                     236.
0157                  READ(5,231) Q(L)                                                   237.
0158                231 FORMAT(E10.3)                                                    238.
0159                240 WRITE(6,241) NUCL1(L),NUCL2(L),NDTR(L),BRANCH(L),LZ(L),RLMDA(L),239.
                     *Q(L),(DCF(M,L),M=1,6)                                              240.
0160                241 FORMAT(1HO,2A4,5X,I1,7X,F4.0,6X,I2,4X,E10.3,2X,E10.3,4X,4E11.3,2X,241.
                     *2E11.3)                                                            242.
                C                                                                        243.
                C          CHECK AGAINST ZERO FLOW AND  FIRST DAUGHTER.                  244.
                C                                                                        245.
0161                  IF(FLOW(1).GT.0.01) GO TO 248                                      246.
0162                  WRITE(6,246)                                                       247.
0163                  STOP                                                               248.
0164                246 FORMAT(1HO,'FLOW IN FIRST LOCATION CANNOT BE ZERO. EXEC. TERM.') 249.
0165                248 IF(NDTR(1).NE.1)  GO TO 249                                      250.
0166                  WRITE(6,247)                                                       251.
0167                  STOP                                                               252.
0168                247 FORMAT(1HO,'FIRST NUCLIDE CANNOT BE A DAUGHTER. EXECUTION TERM.') 253.
                C                                                                        254.
                C     CALC. CONCS. AT FIRST LOCATION. CHANGE UNITS FROM                  255.
                C     CURIES/YR PER CFS TO MICROCI / ML                                  256.
                C                                                                        257.
0169                249 DO 250 L=1,NISO                                                  258.
0170                250 CONC(1,L) = (Q(L) / FLOW (1)) * 1.12E-06                         259.
                C                                                                        260.
                C     PERFORM VARIOUS DATA CHECKS AND CALC. DOWNSTREAM CONCENTRATIONS.   261.
                C                                                                        262.
0171                  TIME(1) =0.                                                        263.
0172                  RMILES(1) = 0.                                                     264.
0173                  DO 300 N=2,NPC                                                     265.
0174                  RMILES(N) = ABS(RIVM(N) - RIVM(1))                                 266.
0175                  IF (RMILES(N).GE.RMILES(N-1)) GO TO 260                            267.
0176                  WRITE(6,255) N                                                     268.
0177                255 FORMAT(1HO,'EXECUTION STOPPED DUE TO ERROR IN INPUT DATA. ',     269.
                     *'LOCATION ',I2,' IS FEWER MILES DOWNSTREAM THAN PREVIOUS ',       270.
                     *'LOCATION.')                                                       271.
0178                  STOP                                                               272.
0179                260 IF (FLOW(N).GE.FLOW(N-1)) GO TO 270                            273.
0180                  WRITE(6,265) N                                                     274.
0181                265 FORMAT(1HO,'EXECUTION STOPPED DUE TO ERROR IN INPUT DATA. ',     275.
                     *'VOLUME FLOW RATE AT LOCATION ',I2,' IS LESS THAN THAT AT ',       276.
                     *'PREVIOUS POINT')                                                  277.
0182                  STOP                                                               278.
0183                270 TIME(N) = TIME(N-1) + (RMILES(N) - RMILES(N-1))/VEL(N)         279.
                C                                                                        280.
0184                  DELAY = (RMILES(N) - RMILES(N-1))*3600./VEL(N)                     281.
0185                  DO 300 L=1,NISO                                                    282.
                C                                                                        283.
0186                  ARGD = RLMDA(L) * DELAY                                            284.
                C                                                                        285.
                C     AVOID UNDERFLOWS.                                                  286.
                C                                                                        287.
0187                  DECAYD = 0.                                                        288.
0188                  IF(ARGD.LT.100.) DECAYD=EXP(-ARGD)                                 289.
                C                                                                        290.
```

Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                  MAIN                DATE = 76225          12/23/13

0189                DLUTE= FLOW(N-1) /(FLOW(N) + VOL(N) * RLMDA(L))                          291.
0190                CONC(N,L) = CONC(N-1,L) * DECAYD * DLUTE                                 292.
               C                                                                             293.
               C     CALC. INGROWTH                                                          294.
               C                                                                             295.
0191                IF(NDTR(L).EQ.1)                                                         296.
                   *  CONC(N,L) = CONC(N,L) + BRANCH(L) / 100. * (CONC(N-1,L-1) *           297.
                   *  RLMDA(L) / (RLMDA(L) - RLMDA(L-1)) * (DECAYP - DECAYD) *              298.
                   *  DLUTE + CONC(N,L-1) * RLMDA(L) * VOL(N) / (RLMDA(L) * VOL(N) +        299.
                   *  FLOW(N)))                                                             300.
               C                                                                             301.
0192             300 DECAYP = DECAYD                                                        302.
               C                                                                             303.
               C                                                                             304.
0193                WRITE(6,310)                                                             305.
0194             310 FORMAT(1H1,/,44X,'RADIONUCLIDE CONCENTRATIONS DOWNSTREAM',/,49X,       306.
                   *'(MICROCURIES PER MILLILITER)'/)                                        307.
0195                IF(NISO.LT.10) NMIN=NISO                                                 308.
0196                IF(NISO.GE.10) NMIN=10                                                   309.
0197                WRITE(6,311) ((L),L=1,NMIN)                                              310.
0198             311 FORMAT(1HO,/,25X,10(4X,I2,4X))                                         311.
0199                WRITE(6,312) ((NUCL1(L),NUCL2(L)),L=1,NMIN)                              312.
0200             312 FORMAT(1HO,27X,10(2A4,2X))                                             313.
0201                DO 315 N=1,NPC                                                           314.
0202             315 WRITE(6,316) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),                315.
                   *(CONC(N,L),L=1,NMIN)                                                    316.
0203             316 FORMAT(1HO,I2,'.',1X,5A4,10E10.2)                                      317.
0204                IF(NISO.LT.11.) GO TO 400                                                318.
0205                WRITE(6,311) ((L),L=11,NISO)                                             319.
0206                WRITE(6,312) ((NUCL1(L),NUCL2(L)),L=11,NISO)                             320.
0207                DO 325 N=1,NPC                                                           321.
0208             325 WRITE(6,316) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),                322.
                   *(CONC(N,L),L=11,NISO)                                                   323.
               C                                                                             324.
               C                                                                             325.
               C      CALCULATE WATER INGESTION DOSES BY NUCLIDE, REACH AND ORGAN            326.
               C      AND SUM OVER NUCLIDES IN EACH REACH.                                   327.
               C                                                                             328.
0209             400 DRINKS=1.95                                                            329.
0210                HOURS = 100.                                                             330.
0211                DO 420 N=1,NPC                                                           331.
0212                IF(POP(N).EQ.0.) GO TO 420                                               332.
0213                B=POP(N)*DRINKS*365.25*1.E+06                                            333.
0214                DO 410 M=1,4                                                             334.
0215                D=0.                                                                     335.
0216                DO 405 L=1,NISO                                                          336.
0217                DPWTR(N,L,M)=CONC(N,L)*DCF(M,L)*B                                        337.
0218             405 D = D + DPWTR(N,L,M)                                                   338.
0219             410 DWTRNM(N,M)=D                                                          339.
               C                                                                             340.
               C     CALCULATE SWIMMING DOSES AND SUM IN REACHES                             341.
               C                                                                             342.
0220                B=1.     *HOURS*1.E+06                                                   343.
0221                DO 420 M=5,6                                                             344.
0222                D=0.                                                                     345.
0223                DO 415 L=1,NISO                                                          346.
0224                DPWTR(N,L,M)=CONC(N,L)*DCF(M,L)*B                                        347.
0225             415 D=D+DPWTR(N,L,M)                                                        348.
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Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                MAIN                DATE = 76226          12/23/13

0226                  DWTRNM(N,M) = D                                                    349.
0227              420 CONTINUE                                                           350.
                  C                                                                      351.
                  C                                                                      352.
                  C       WRITE DRINKING WATER AND SWIMMING DOSES AT ALL LOCATIONS       353.
0228                  IF(NPRINT.NE.1)  GO TO 440                                         354.
                  C                                                                      355.
0229                  DO 440 N=1,NPC                                                     356.
0230                  IF(POP(N).EQ.0.) GO TO 440                                         357.
0231                  WRITE(6,430) DRINKS,HOURS                                          358.
0232              430 FORMAT(1H1,30X,'DRINKING WATER AND SWIMMING'/,34X,'POPULATION ',   359.
                     *'DOSE RATES'/,25X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)'//22X,   360.
                     *'ASSUMING: 1) UNIFORM RELEASE RATES'/,31X,'2A) DRINKING: CONTI',   361.
                     *'NUOUS INGESTION RATE'/,35X,'OF ',F4.2,' LITERS PER DAY'/,31X,     362.
                     *'2B) SWIMMING: ',F5.0,' HOURS OF IMMERSION'/,35X,'PER YEAR',       363.
                     *' - ONE PERSON PER REACH')                                         364.
                  C                                                                      365.
                  C       WRITE LOCATION DATA                                            366.
                  C                                                                      367.
0233                  WRITE(6,432) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),RMILES(N),  368.
                     *POP(N)                                                             369.
0234              432 FORMAT(1HO,1X,'LOCATION',10X,'NAME',10X,'MILES DOWNSTREAM',3X,     370.
                     *'POPULATION SERVED',                                               371.
                     */,3X,I4,5X,5A4,3X,F10.2,10X,F10.0)                                 372.
                  C                                                                      373.
                  C        WRITE POPULATION DOSES BY NUCLIDE AND ORGAN,                  374.
                  C        WITH SUBTOTALS FOR EACH REACH BY ORGAN.                       375.
                  C                                                                      376.
0235                  WRITE(6,434) ((NMOGN1(M),NMOGN2(M)),M=1,6)                         377.
0236              434 FORMAT(1HO,1X,'NUCLIDE',4X,'CURIES     DRINKING WATER DOSES (4 ',  378.
                     *'CRITICAL ORGANS)',8X,'SWIMMING DOSES'/,12X,'RELEASED',1X,         379.
                     *4(3X,2A4),2X,2(3X,2A4))                                            380.
0237                  DO 435 L=1,NISO                                                    381.
0238              435 WRITE(6,436) NUCL1(L),NUCL2(L),Q(L),(DPWTR(N,L,M),M=1,6)           382.
0239              436 FORMAT(1HO,1X,2A4,E10.2,1X,4E11.2,2X,2E11.2)                       383.
0240                  WRITE(6,438) (DWTRNM(N,M),M=1,6)                                   384.
0241              438 FORMAT(1HO,6X,'SUBTOTALS',5X,4E11.2,2X,2E11.2/)                    385.
0242              440 CONTINUE                                                           386.
                  C                                                                      387.
                  C                                                                      388.
                  C        SUM TOTAL DRINKING WATER ORGAN DOSES FOR RUN                  389.
                  C                                                                      390.
0243                  DO 455 M=1,6                                                       391.
0244                  D=0.                                                               392.
0245                  DO 450 N=1,NPC                                                     393.
0246              450 D=D+DWTRNM(N,M)                                                    394.
0247              455 DPWTRM(M) = D                                                      395.
                  C                                                                      396.
                  C       CALCULATE COMMERCIAL AND CREEL FISH INGESTION DOSES.           397.
                  C                                                                      398.
0248                  CATUSE=1.-2523./4940.                                              399.
0249                  CATEAT=.45                                                         400.
0250                  CTLEFT=.80                                                         401.
0251                  A1 = CATUSE*CATEAT*CTLEFT*.4535E+06                                402.
0252                  A2 = CATEAT*CTLEFT*.4535E+06                                       403.
0253                  DO 520 N=1,NPC                                                     404.
0254                  IF(CTCHWT(N,1).GT.0.) GO TO 510                                    405.
0255                  IF(CTCHWT(N,2).LE.0.) GO TO 520                                    406.
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Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                MAIN              DATE = 76226          12/23/13

0256          510 B1=CTCHWT(N,1)*A1                                                    407.
0257              B2=CTCHWT(N,2)*A2                                                    408.
0258              DO 520 L=1,NISO                                                      409.
0259              D1=B1*CONC(N,L)*RECONC(LZ(L))                                        410.
0260              D2=B2*CONC(N,L)*RECONC(LZ(L))                                        411.
0261              DO 519 M=1,4                                                         412.
0262              DPCML(N,L,M)=D1*DCF(M,L)                                             413.
0263              DPCRL(N,L,M)=D2*DCF(M,L)                                             414.
0264          519 CONTINUE                                                             415.
0265          520 CONTINUE                                                             416.
            C                                                                        417.
            C     SUM FISH DOSES IN REACHES AND TOTAL FISH DOSE BY ORGAN              418.
            C                                                                        419.
0266              DO 540 M=1,4                                                         420.
0267              F=0.                                                                 421.
0268              D=0.                                                                 422.
0269              DO 535 N=1,NPC                                                       423.
0270              IF(CTCHWT(N,1).GT.0.) GO TO 525                                      424.
0271              IF(CTCHWT(N,2).LE.0.) GO TO 535                                      425.
0272          525 H=0.                                                                 426.
0273              E=0.                                                                 427.
0274              DO 530 L=1,NISO                                                      428.
0275              H = H + DPCRL(N,L,M)                                                 429.
0276          530 E = E + DPCML(N,L,M)                                                 430.
0277              DCRLNM(N,M) = H                                                      431.
0278              DCMLNM(N,M) = E                                                      432.
0279              F = F + DCRLNM(N,M)                                                  433.
0280              D = D + DCMLNM(N,M)                                                  434.
0281          535 CONTINUE                                                             435.
0282              DPCRLM(M) = F                                                        436.
0283          540 DPCMLM(M) = D                                                        437.
            C                                                                        438.
            C     WRITE FISH INGESTION POPULATION DOSES IN REACHES                    439.
            C                                                                        440.
0284              I=(CATUSE+.005)*100.                                                 441.
0285              J=(CATEAT+.005)*100.                                                 442.
0286              K=(CTLEFT+.005)*100.                                                 443.
0287              IF(NPRINT.NE.1)  GO TO 580                                           444.
0288              DO 570 N=1,NPC                                                       445.
0289              IF(CTCHWT(N,1).LE.0.) GO TO 570                                      446.
0290              WRITE(6,550)                                                         447.
0291          550 FORMAT(1H1,22X,'COMMERCIAL FISH INGESTION POPULATION DOSE RATES',    448.
                 */,27X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)')                   449.
0292              WRITE(6,551) I,J,K                                                   450.
0293          551 FORMAT(1HO,22X,'ASSUMING: 1) UNIFORM INGESTION RATES'/,33X,          451.
                 *'2) ',I2,                                                          452.
                 *' PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION' 453.
                 */,33X,'3) ',I2,' PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY', 454.
                 *' INGESTED'/,33X,'4) ',I2,' PERCENT OF NUCLIDE REMAINS IN FISH',   455.
                 *' AFTER COOKING'//)                                                456.
            C                                                                        457.
0294              WRITE(6,560) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),RMILES(N),  458.
                 *CTCHWT(N,1)                                                        459.
0295          560 FORMAT(1HO,1X,'LOCATION',10X,'NAME',10X,'MILES DOWNSTREAM',3X,      460.
                 *'COMMERCIAL FISH CAUGHT (LBS)',                                    461.
                 */,3X,I4,5X,5A4,3X,F10.2,16X,F10.0)                                 462.
0296              WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)                           463.
0297          564 FORMAT(1HO,1X,'NUCLIDE',4X,'CURIES',4X,4(2A4,3X)/,12X,'RELEASED')   464.
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Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                MAIN              DATE = 76226          12/23/13

0298                  DO 566 L=1,NISO                                                    465.
0299               566 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(DPCML(N,L,M),M=1,4)          466.
0300               567 FORMAT(1HO,1X,2A4,F10.2,4E11.2)                                   467.
0301                   WRITE(6,568) (DCMLNM(N,M),M=1,4)                                  468.
0302               568 FORMAT(1HO,6X,'SUBTOTALS',4X,4F11.2)                              469.
0303               570 CONTINUE                                                          470.
                   C                                                                     471.
                   C                                                                     472.
0304                   DO 580 N=1,NPC                                                    473.
0305                   IF(CTCHWT(N,2).LE.0.) GO TO 580                                   474.
0306                   WRITE(6,572)                                                      475.
0307               572 FORMAT(1H1,22X,'CREEL FISH INGESTION POPULATION DOSE RATES',      476.
                      */,24X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)',/)                477.
0308                   WRITE(6,573) J,K                                                  478.
0309               573 FORMAT(1HO,22X,'ASSUMING: 1) UNIFORM INGESTION RATES'/,33X,       479.
                      *'2) ALL CREEL FISH ARE IMMEDIATELY EATEN',                        480.
                      */,33X,'3) ',I2,' PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY',481.
                      *' INGESTED'/,33X,'4) ',I2,' PERCENT OF NUCLIDE REMAINS IN FISH',  482.
                      *' AFTER COOKING'//)                                               483.
                   C                                                                     484.
0310                   WRITE(6,574) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),RMILES(N),485.
                      *CTCHWT(N,2)                                                       486.
0311               574 FORMAT(1HO,1X,'LOCATION',10X,'NAME',10X,'MILES DOWNSTREAM',3X,    487.
                      *'CREEL FISH CAUGHT (LBS)',                                        488.
                      */,3X,I4,5X,5A4,3X,F10.2,13X,F10.0)                                489.
0312                   WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)                        490.
0313                   DO 576 L=1,NISO                                                   491.
0314               576 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(DPCRL(N,L,M),M=1,4)          492.
0315                   WRITE(6,568) (DCRLNM(N,M),M=1,4)                                  493.
0316               580 CONTINUE                                                          494.
                   C                                                                     495.
                   C      SUM DOSES OVER ALL LOCATIONS                                   496.
                   C                                                                     497.
0317                   DO 620 L=1,NISO                                                   498.
0318                   DO 610 M=1,6                                                      499.
0319                   S1=0.                                                             500.
0320                   DO 600 N=1,NPC                                                    501.
0321               600 S1=S1+DPWTR(N,L,M)                                                502.
0322               610 WTRTOT(L,M)=S1                                                    503.
0323                   DO 620 M=1,4                                                      504.
0324                   S2=0.                                                             505.
0325                   S3=0.                                                             506.
0326                   DO 615 N=1,NPC                                                    507.
0327                   S2=S2+DPCML(N,L,M)                                                508.
0328               615 S3=S3+DPCRL(N,L,M)                                                509.
0329                   CMLTOT(L,M)=S2                                                    510.
0330               620 CRLTOT(L,M)=S3                                                    511.
                   C                                                                     512.
                   C                                                                     513.
                   C      WRITE SUMMARY FOR WHOLE RUN                                    514.
                   C                                                                     515.
0331                   WRITE(6,621) FAC1,FAC2,FAC3,FAC4,FAC5                             516.
0332               621 FORMAT(1H1,21X,'SUMMARY OF RVRDOS(02) RUN FOR ',5A4)              517.
0333                   WRITE(6,431) DRINKS                                               518.
0334               431 FORMAT(1H1,37X,'DRINKING WATER'/,34X,'POPULATION ',               519.
                      *'DOSE RATES'/,25X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)'//22X, 520.
                      *'ASSUMING: 1) UNIFORM RELEASE RATES'/,31X,'2) DRINKING: CONTI',   521.
                      *'NUOUS INGESTION RATE'/,35X,'OF ',F4.2,' LITERS PER DAY')         522.
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Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                MAIN              DATE = 76226          12/23/13

0335            WRITE(6,622)                                                          523.
0336          622 FORMAT(1HO,23X,'DOSES BY NUCLIDE, SUMMED OVER LOCATIONS')           524.
0337            WRITE(6,6221) ((NMOGN1(M),NMOGN2(M)),M=1,4)                           525.
0338         6221 FORMAT(1HO,1X,'NUCLIDE',4X,'CURIES     DRINKING WATER DOSES (4 ',   526.
                *'CRITICAL ORGANS)'/12X,'RELEASED',1X,4(3X,2A4),2X,2(3X,2A4))        527.
0339            DO 623 L=1,NISO                                                       528.
0340          623 WRITE(6,435) NUCL1(L),NUCL2(L),Q(L),(WTRTOT(L,M),M=1,4)             529.
0341            WRITE(6,624) (DPWTRM(M),M=1,4)                                        530.
0342          624 FORMAT(1HO,8X,'TOTALS',6X,4E11.2,2X,2E11.2)                         531.
0343            WRITE(6,431) DRINKS                                                   532.
0344            WRITE(6,626)                                                          533.
0345          626 FORMAT(1HO,23X,'DOSES BY LOCATION, SUMMED OVER NUCLIDES')           534.
0346            WRITE(6,627) ((NMOGN1(M),NMOGN2(M)),M=1,4)                            535.
0347          627 FORMAT(1HO,4X,'LOCATION',16X,'MILES     POPULATION    DRINKING ',   536.
               *'WATER DOSES (4 CRITICAL ORGANS)',/,27X,                              537.
               *'DOWNSTREAM    SERVED',3X,4(3X,2A4),2X,2(3X,2A4))                     538.
0348            DO 630 N=1,NPC                                                        539.
0349          630 WRITE(6,631) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),             540.
               *RMILES(N),POP(N),(DWTRNM(N,M),M=1,4)                                  541.
0350          631 FORMAT(1HO,I2,'. ',5A4,F9.1,3X,F10.0,3X,4E11.2,2X,2E11.2)           542.
0351            WRITE(6,632) TOTPOP,(DPWTRM(M),M=1,4)                                 543.
0352          632 FORMAT(1HO,4X,'TOTALS',28X,F10.0,4E11.2,2X,2E11.2)                  544.
0353            WRITE(6,550)                                                          545.
0354            WRITE(6,551) I,J,K                                                    546.
0355            WRITE(6,622)                                                          547.
0356            WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)                            548.
0357            DO 700 L=1,NISO                                                       549.
0358          700 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(CMLTOT(L,M),M=1,4)             550.
0359            WRITE(6,701) (DPCMLM(M),M=1,4)                                        551.
0360          701 FORMAT(1HO,9X,'TOTALS',5X,4E11.2)                                   552.
0361            WRITE(6,550)                                                          553.
0362            WRITE(6,551) I,J,K                                                    554.
0363            WRITE(6,626)                                                          555.
0364            WRITE(6,710) ((NMOGN1(M),NMOGN2(M)),M=1,4)                            556.
0365          710 FORMAT(1HO,4X,'LOCATION',16X,'MILES     COMMERCIAL FISH ',        557.
               *4(3X,2A4),/,27X,'DOWNSTREAM   CAUGHT (LBS)')                          558.
0366            DO 720 N=1,NPC                                                        559.
0367          720 WRITE(6,721) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),             560.
               *RMILES(N),CTCHWT(N,1),(DCMLNM(N,M),M=1,4)                             561.
0368          721 FORMAT(1HO,I2,'. ',5A4,F9.1,5X,F10.0,5X,4E11.2)                     562.
0369            WRITE(6,722) TOTCML,(DPCMLM(M),M=1,4)                                 563.
0370          722 FORMAT(1HO,4X,'TOTALS',33X,F10.0,4E11.2)                            564.
0371            WRITE(6,572)                                                          565.
0372            WRITE(6,573) J,K                                                      566.
0373            WRITE(6,622)                                                          567.
0374            WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)                            568.
0375            DO 800 L=1,NISO                                                       569.
0376          800 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(CRLTOT(L,M),M=1,4)             570.
0377            WRITE(6,701) (DPCRLM(M),M=1,4)                                        571.
0378            WRITE(6,572)                                                          572.
0379            WRITE(6,573) J,K                                                      573.
0380            WRITE(6,626)                                                          574.
0381            WRITE(6,810) ((NMOGN1(M),NMOGN2(M)),M=1,4)                            575.
0382          810 FORMAT(1HO,4X,'LOCATION',16X,'MILES        CREEL FISH   ',        576.
               *4(3X,2A4),/,27X,'DOWNSTREAM   CAUGHT (LBS)')                          577.
0383            DO 820 N=1,NPC                                                        578.
0384          820 WRITE(6,721) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),             579.
               *RMILES(N),CTCHWT(N,2),(DCRLNM(N,M),M=1,4)                             580.
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Listing of source program for RVRDOS (continued)

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FORTRAN IV G LEVEL  21                  MAIN                DATE = 76225          12/23/13

0385                    WRITE(6,722) TOTCRL,(DPCRLM(M),M=1,4)                                  591.
0386                    WRITE(6,723)                                                           592.
0387                723 FORMAT(1H1,21X,'TRAVEL TIME TO DOWNSTREAM POINTS (HRS.)')              593.
0388                    DO 930 N=1,NPC                                                         594.
0389                830 WRITE(6,724) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),TIME(N)         595.
0390                724 FORMAT(1H0,I2,'. ',5A4,F10.1)                                          596.
                    C                                                                      597.
0391                    WRITE(6,901)                                                           598.
0392                901 FORMAT(1H1)                                                            599.
0393                    GO TO 900                                                              600.
                    C                                                                      601.
0394                999 CALL EXIT                                                              602.
0395                    STOP                                                                   603.
0396                    END                                                                    604.
```

Listing of source program for RVRDOS (continued)

PROGRAM RVRDOS

FOR INFORMATION REGARDING THIS PROGRAM, CONTACT:

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
401 M ST SW
WASHINGTON, DC 20460

INPUT DATA

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
GENOA (LACROSSE)	1973	12	

LOCATIONS ON STREAM (TOTAL OF 29, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	GENOA	1.	275.	1.9	-1633.3	0.	0.	111.
2	LOCK AND DAM 3	0.	29139.	1.9	-1633.0	100400.	1112264.	0.
3	LOCK AND DAM 9	0.	30691.	1.9	-1603.8	195800.	2040760.	0.
4	LOCK AND DAM 10	0.	34277.	1.9	-1571.0	149700.	675405.	0.
5	LOCK AND DAM 11	0.	38585.	1.9	-1539.9	157400.	528808.	142927.
6	LOCK AND DAM 12	0.	44778.	1.9	-1510.5	88400.	405587.	0.
7	LOCK AND DAM 13	0.	46679.	1.9	-1478.3	185600.	984603.	118932.
8	LOCK AND DAM 14	0.	49660.	1.9	-1449.1	80000.	396522.	0.
9	BETTENDORF-MOLINE	55555.	50363.	1.9	-1441.8	30000.	151214.	0.
10	DAVENPORT-ROCKISLAND	141580.	50652.	1.9	-1438.8	89400.	458510.	0.
11	LOCK AND DAM 17	0.	55065.	1.9	-1393.0	51400.	450113.	0.
12	LOCK AND DAM 18	0.	57638.	1.9	-1366.3	95800.	928489.	83669.
13	BURLINGTON, IOWA	35400.	58245.	1.9	-1360.0	0.	0.	0.
14	TR. MADISON	15245.	50335.	1.9	-1339.3	0.	0.	0.
15	KEOKUK, LED 19	16315.	62119.	1.9	-1319.9	214000.	920778.	0.
16	LOCK AND DAM 20	0.	66636.	1.9	-1299.0	73600.	75657.	0.
17	QUINCY, ILL.	47500.	70155.	1.9	-1282.8	76400.	138218.	0.
18	HANNIBAL, MO.	21000.	74065.	1.9	-1264.9	91000.	129689.	0.
19	LOCK AND DAM 24	0.	81775.	1.9	-1229.8	29745.	214530.	0.

Genoa: Input data

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Genoa: Input data (continued)

20	LOCK AND DAM 25	0.	99727.	1.9	-1197.3	49674.	336105.	0.
21	LOCK AND DAM 26	0.	97090.	1.9	-1153.9	107092.	353487.	38751.
22	LOCK AND DAM 27	40073.	157739.	1.9	-1141.1	0.	264390.	0.
23	ST.LOUIS,E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
24	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
25	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
26	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
27	VICKSBURG, MISS.	41000.	574000.	3.2	-439.0	0.	0.	0.
28	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
29	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 20)

ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	DOSE CONVERSION FACTORS INGESTION MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE BODY	THYROID	BONE	GI-LLI	SWIMMING MREM/HR PER PCI/LITER SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.740E-01	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-06	0.118E+02	0.168E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05
CO-60	0	0.	27	0.418E-08	0.126E+01	0.470E-05	0.0	0.0	0.394E-04	0.540E-05	0.460E-05
CR-51	0	0.	24	0.299E-06	0.810E-01	0.267E-09	0.159E-09	0.0	0.669E-06	0.640E-07	0.520E-07
CS-134	0	0.	55	0.107E-07	0.565E+01	0.100E-03	0.0	0.529E-04	0.256E-05	0.350E-05	0.290E-05
CS-137	0	0.	55	0.733E-09	0.101E+02	0.560E-04	0.0	0.637E-04	0.205E-05	0.140E-05	0.100E-05
BA-137M	1	100.	56	0.163E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3	0	0.	1	0.179E-08	0.103E+03	0.127E-05	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.313E+01	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06
XE-131M	1	1.	54	0.680E-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
I-133	0	0.	53	0.916E-05	0.289E+01	0.702E-06	0.492E-03	0.143E-05	0.225E-05	0.150E-05	0.960E-06
XE-133	1	100.	54	0.152E-05	0.430E+00	0.0	0.0	0.0	0.0	0.110E-06	0.570E-07
MN-54	0	0.	25	0.265E-07	0.950E-01	0.869E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.500E-01	0.913E-05	0.0	0.320E-03	0.499E-04	0.540E-06	0.460E-08
Y-83M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	39	0.778E-09	0.210E-01	0.995E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07

XE-135	0	0.	54	0.209E-04	0.180E+00	0.0	0.0	0.0	0.0	0.790E-06	0.450E-06
CS-135	0	0.	55	0.730E-14	0.0	0.564E-05	0.0	0.144E-04	0.371E-07	0.110E-07	0.660E-10
ZN-65	0	0.	30	0.328E-07	0.216E+00	0.509E-05	0.0	0.345E-05	0.379E-05	0.120E-05	0.110E-05

Genoa: Input data
(continued)

Genoa: Radionuclide concentrations by downstream location

RADIONUCLIDE CONCENTRATIONS DOWNSTREAM
(MICROCURIES PER MILLILITER)

	1	2	3	4	5	6	7	8	9	10
	BALA-140	CO-58	CO-60	CR-51	CS-134	CS-137	BA-137M	H-3	I-131	XE-131M
1. GENOA	0.30E-09	0.48E-07	0.51E-08	0.33E-09	0.23E-07	0.41E-07	0.0	0.42E-06	0.13E-07	0.0
2. LOCK AND DAM 8	0.68E-12	0.46E-09	0.50E-10	0.31E-11	0.22E-09	0.40E-09	0.40E-09	0.41E-08	0.11E-09	0.10E-12
3. LOCK AND DAM 9	0.28E-13	0.41E-09	0.46E-10	0.26E-11	0.21E-09	0.37E-09	0.37E-09	0.38E-08	0.73E-10	0.22E-12
4. LOCK AND DAM 10	0.14E-14	0.35E-09	0.41E-10	0.21E-11	0.18E-09	0.33E-09	0.33E-09	0.34E-08	0.52E-10	0.25E-12
5. LOCK AND DAM 11	0.70E-16	0.31E-09	0.37E-10	0.18E-11	0.16E-09	0.29E-09	0.29E-09	0.30E-08	0.37E-10	0.25E-12
6. LOCK AND DAM 12	0.69E-17	0.26E-09	0.31E-10	0.15E-11	0.14E-09	0.25E-09	0.25E-09	0.26E-08	0.28E-10	0.22E-12
7. LOCK AND DAM 13	0.40E-18	0.24E-09	0.30E-10	0.13E-11	0.13E-09	0.24E-09	0.24E-09	0.25E-08	0.21E-10	0.21E-12
8. LOCK AND DAM 14	0.47E-19	0.23E-09	0.28E-10	0.12E-11	0.13E-09	0.23E-09	0.23E-09	0.23E-08	0.18E-10	0.20E-12
9. BETTENDORF-MOLINE	0.22E-19	0.22E-09	0.29E-10	0.12E-11	0.12E-09	0.22E-09	0.22E-09	0.23E-08	0.17E-10	0.20E-12
10. DAVENPORT-ROCKISLAND	0.75E-20	0.22E-09	0.28E-10	0.11E-11	0.12E-09	0.22E-09	0.22E-09	0.23E-08	0.15E-10	0.19E-12
11. LOCK AND DAM 17	0.59E-21	0.20E-09	0.26E-10	0.10E-11	0.11E-09	0.20E-09	0.20E-09	0.21E-08	0.13E-10	0.17E-12
12. LOCK AND DAM 18	0.77E-22	0.19E-09	0.24E-10	0.93E-12	0.11E-09	0.20E-09	0.20E-09	0.20E-08	0.11E-10	0.16E-12
13. BURLINGTON, IOWA	0.59E-22	0.18E-09	0.24E-10	0.92E-12	0.11E-09	0.19E-09	0.19E-09	0.20E-08	0.10E-10	0.15E-12
14. FT. MADISON	0.24E-22	0.18E-09	0.23E-10	0.87E-12	0.10E-09	0.19E-09	0.19E-09	0.19E-08	0.96E-11	0.15E-12
15. KEOKUK, L&D 19	0.27E-23	0.17E-09	0.23E-10	0.81E-12	0.10E-09	0.18E-09	0.18E-09	0.19E-08	0.78E-11	0.14E-12
16. LOCK AND DAM 20	0.54E-24	0.16E-09	0.21E-10	0.73E-12	0.93E-10	0.17E-09	0.17E-09	0.17E-08	0.67E-11	0.13E-12
17. QUINCY, ILL.	0.13E-24	0.15E-09	0.20E-10	0.68E-12	0.88E-10	0.16E-09	0.16E-09	0.16E-08	0.59E-11	0.12E-12
18. HANNIBAL, MO.	0.29E-25	0.14E-09	0.19E-10	0.63E-12	0.84E-10	0.15E-09	0.15E-09	0.16E-08	0.51E-11	0.11E-12
19. LOCK AND DAM 24	0.48E-26	0.12E-09	0.17E-10	0.56E-12	0.76E-10	0.14E-09	0.14E-09	0.14E-08	0.43E-11	0.95E-13
20. LOCK AND DAM 25	0.90E-27	0.11E-09	0.16E-10	0.50E-12	0.70E-10	0.13E-09	0.13E-09	0.13E-08	0.36E-11	0.85E-13
21. LOCK AND DAM 26	0.78E-28	0.10E-09	0.14E-10	0.44E-12	0.64E-10	0.12E-09	0.12E-09	0.12E-08	0.29E-11	0.74E-13
22. LOCK AND DAM 27	0.24E-28	0.62E-10	0.89E-11	0.27E-12	0.39E-10	0.71E-10	0.71E-10	0.73E-09	0.17E-11	0.45E-13
23. ST.LOUIS,E.ST.LOUIS	0.17E-28	0.56E-10	0.80E-11	0.24E-12	0.35E-10	0.64E-10	0.64E-10	0.65E-09	0.16E-11	0.40E-13
24. CHESTER, ILL.	0.26E-29	0.54E-10	0.77E-11	0.23E-12	0.34E-10	0.62E-10	0.62E-10	0.64E-09	0.14E-11	0.38E-13
25. CAPE GIRARDEAU, MO.	0.57E-30	0.52E-10	0.76E-11	0.22E-12	0.33E-10	0.61E-10	0.61E-10	0.62E-09	0.13E-11	0.36E-13
26. THEBES, ILL.	0.46E-30	0.52E-10	0.76E-11	0.22E-12	0.33E-10	0.61E-10	0.61E-10	0.62E-09	0.12E-11	0.35E-13

27. VICKSBURG, MISS.	0.29E-36	0.16E-10	0.24E-11	0.59E-13	0.11E-10	0.20E-10	0.20E-10	0.20E-09	0.22E-12	0.85E-14
28. DONALDSVILLE, LA.	0.62E-39	0.15E-10	0.24E-11	0.53E-13	0.11E-10	0.19E-10	0.19E-10	0.20E-09	0.16E-12	0.72E-14
29. NEW ORLEANS, LA.	0.10E-39	0.15E-10	0.24E-11	0.52E-13	0.11E-10	0.19E-10	0.19E-10	0.20E-09	0.15E-12	0.69E-14

	11	12	13	14	15	16	17	18	19	20
	I-133	XE-133	MN-54	SR-89	Y-89M	SR-90	Y-90	XE-135	CS-135	ZN-65
1. GENOA	0.12E-07	0.17E-08	0.35E-09	0.20E-09	0.0	0.95E-10	0.0	0.73E-09	0.0	0.98E-09
2. LOCK AND DAM 8	0.47E-10	0.23E-10	0.34E-11	0.19E-11	0.17E-15	0.83E-12	0.27E-12	0.17E-11	0.0	0.85E-11
3. LOCK AND DAM 9	0.74E-11	0.19E-10	0.31E-11	0.17E-11	0.15E-15	0.77E-12	0.53E-12	0.71E-13	0.0	0.79E-11
4. LOCK AND DAM 10	0.14E-11	0.12E-10	0.27E-11	0.15E-11	0.13E-15	0.69E-12	0.57E-12	0.35E-14	0.0	0.69E-11
5. LOCK AND DAM 11	0.26E-12	0.77E-11	0.24E-11	0.13E-11	0.11E-15	0.61E-12	0.55E-12	0.18E-15	0.0	0.61E-11
6. LOCK AND DAM 12	0.78E-13	0.54E-11	0.21E-11	0.11E-11	0.95E-16	0.52E-12	0.49E-12	0.18E-16	0.0	0.52E-11
7. LOCK AND DAM 13	0.16E-13	0.37E-11	0.20E-11	0.98E-12	0.88E-16	0.50E-12	0.49E-12	0.11E-17	0.0	0.50E-11
8. LOCK AND DAM 14	0.57E-14	0.29E-11	0.19E-11	0.90E-12	0.81E-16	0.47E-12	0.46E-12	0.13E-18	0.0	0.46E-11
9. BETTENDORF-MOLINE	0.40E-14	0.27E-11	0.19E-11	0.88E-12	0.79E-16	0.47E-12	0.46E-12	0.61E-19	0.0	0.46E-11
10. DAVENPORT-ROCKISLAND	0.22E-14	0.24E-11	0.18E-11	0.87E-12	0.79E-16	0.46E-12	0.46E-12	0.21E-19	0.0	0.45E-11
11. LOCK AND DAM 17	0.67E-15	0.18E-11	0.17E-11	0.79E-12	0.70E-16	0.43E-12	0.42E-12	0.17E-20	0.0	0.42E-11
12. LOCK AND DAM 18	0.24E-15	0.15E-11	0.16E-11	0.73E-12	0.66E-16	0.41E-12	0.40E-12	0.22E-21	0.0	0.40E-11
13. BURLINGTON, IOWA	0.21E-15	0.14E-11	0.15E-11	0.72E-12	0.65E-16	0.40E-12	0.40E-12	0.17E-21	0.0	0.39E-11
14. FT. MADISON	0.14E-15	0.13E-11	0.15E-11	0.69E-12	0.62E-16	0.39E-12	0.39E-12	0.70E-22	0.0	0.38E-11
15. KEOKUK, L&D 19	0.42E-16	0.96E-12	0.15E-11	0.66E-12	0.59E-16	0.38E-12	0.38E-12	0.79E-23	0.0	0.36E-11
16. LOCK AND DAM 20	0.19E-16	0.79E-12	0.13E-11	0.60E-12	0.54E-16	0.35E-12	0.35E-12	0.16E-23	0.0	0.34E-11
17. QUINCY, ILL.	0.95E-17	0.66E-12	0.13E-11	0.57E-12	0.51E-16	0.33E-12	0.33E-12	0.40E-24	0.0	0.32E-11
18. HANNIBAL, MO.	0.44E-17	0.55E-12	0.12E-11	0.53E-12	0.48E-16	0.32E-12	0.32E-12	0.89E-25	0.0	0.30E-11
19. LOCK AND DAM 24	0.19E-17	0.44E-12	0.11E-11	0.47E-12	0.43E-16	0.29E-12	0.29E-12	0.15E-25	0.0	0.27E-11
20. LOCK AND DAM 25	0.81E-18	0.36E-12	0.10E-11	0.43E-12	0.39E-16	0.26E-12	0.26E-12	0.25E-26	0.0	0.25E-11
21. LOCK AND DAM 26	0.26E-18	0.27E-12	0.91E-12	0.39E-12	0.35E-16	0.24E-12	0.24E-12	0.25E-27	0.0	0.23E-11
22. LOCK AND DAM 27	0.12E-18	0.16E-12	0.56E-12	0.24E-12	0.21E-16	0.15E-12	0.15E-12	0.77E-28	0.0	0.14E-11
23. ST.LOUIS,E.ST.LOUIS	0.98E-19	0.14E-12	0.50E-12	0.21E-12	0.19E-16	0.13E-12	0.13E-12	0.55E-28	0.0	0.13E-11
24. CHESTER, ILL.	0.43E-19	0.12E-12	0.49E-12	0.20E-12	0.19E-16	0.13E-12	0.13E-12	0.89E-29	0.0	0.12E-11
25. CAPE GIRARDEAU, MO.	0.22E-19	0.11E-12	0.48E-12	0.20E-12	0.18E-16	0.13E-12	0.13E-12	0.19E-29	0.0	0.12E-11

Genoa: Radionuclide concentrations by downstream location
(continued)

Genoa: Radionuclide concentrations by downstream location (continued)

26. THEBES, ILL.	0.20E-19	0.10E-12	0.48E-12	0.20E-12	0.18E-16	0.13E-12	0.13E-12	0.16E-29	0.0	0.12E-11
27. VICKSBURG, MISS.	0.21E-22	0.13E-13	0.15E-12	0.57E-13	0.52E-17	0.41E-13	0.41E-13	0.11E-35	0.0	0.38E-12
28. DONALDSVILLE, LA.	0.15E-23	0.82E-14	0.15E-12	0.54E-13	0.49E-17	0.41E-13	0.41E-13	0.25E-38	0.0	0.37E-12
29. NEW ORLEANS, LA.	0.67E-24	0.72E-14	0.15E-12	0.54E-13	0.48E-17	0.41E-13	0.41E-13	0.42E-39	0.0	0.37E-12

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY NUCLIDE, SUMMED OVER LOCATIONS

NUCLIDE	CURIES RELEASED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
BALA-14C	0.74E-01	0.28E-06	0.0	0.43E-05	0.86E-05
CO-58	0.12E+02	0.14E+00	0.0	0.0	0.13E+01
CO-60	0.13E+01	0.54E-01	0.0	0.0	0.45E+00
CR-51	0.81E-01	0.10E-05	0.62E-06	0.0	0.26E-03
CS-134	0.57E+01	0.50E+01	0.0	0.27E+01	0.13E+00
CS-137	0.10E+02	0.51E+01	0.0	0.58E+01	0.19E+00
BA-137M	0.0	0.0	0.0	0.0	0.0
H-3	0.10E+03	0.12E+00	0.12E+00	0.0	0.60E-01
I-131	0.31E+01	0.13E-01	0.72E+01	0.15E-01	0.59E-02
XE-131M	0.0	0.0	0.0	0.0	0.0
I-133	0.29E+01	0.61E-05	0.42E-02	0.13E-04	0.20E-04
XE-133	0.43E+00	0.0	0.0	0.0	0.0
MN-54	0.85E-01	0.63E-03	0.0	0.0	0.10E-01
SR-89	0.50E-01	0.29E-02	0.0	0.10E+00	0.16E-01
Y-89M	0.0	0.0	0.0	0.0	0.0
SR-90	0.21E-01	0.17E+00	0.0	0.64E-01	0.23E-01
Y-90	0.0	0.54E-07	0.0	0.19E-05	0.20E-01
XE-135	0.18E+00	0.0	0.0	0.0	0.0
CS-135	0.0	0.0	0.0	0.0	0.0
ZN-65	0.22E+00	0.93E-02	0.0	0.53E-02	0.18E-01
TOTALS		0.11E+02	0.73E+01	0.97E+01	0.22E+01

Genoa: Drinking water doses by nuclide

Genoa: Drinking water doses by location

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. GENOA	0.0	1.	0.35E-02	0.21E-01	0.28E-02	0.85E-03
2. LOCK AND DAM 8	0.3	0.	0.0	0.0	0.0	0.0
3. LOCK AND DAM 9	29.5	0.	0.0	0.0	0.0	0.0
4. LOCK AND DAM 10	62.3	0.	0.0	0.0	0.0	0.0
5. LOCK AND DAM 11	94.5	0.	0.0	0.0	0.0	0.0
6. LOCK AND DAM 12	122.8	0.	0.0	0.0	0.0	0.0
7. LOCK AND DAM 13	155.0	0.	0.0	0.0	0.0	0.0
8. LOCK AND DAM 14	184.2	0.	0.0	0.0	0.0	0.0
9. BETTENDORF-MOLINE	191.5	55555.	0.10E+01	0.12E+01	0.84E+00	0.22E+00
10. DAVENPORT-ROCKISLAND	194.5	141580.	0.26E+01	0.29E+01	0.21E+01	0.56E+00
11. LOCK AND DAM 17	240.3	0.	0.0	0.0	0.0	0.0
12. LOCK AND DAM 18	267.0	0.	0.0	0.0	0.0	0.0
13. BURLINGTON, IOWA	273.3	35400.	0.57E+00	0.69E+00	0.46E+00	0.12E+00
14. FT. MADISON	295.0	15245.	0.24E+00	0.28E+00	0.19E+00	0.50E-01
15. KEOKUK, L&D 19	313.5	16315.	0.25E+00	0.17E+00	0.20E+00	0.51E-01
16. LOCK AND DAM 20	334.3	0.	0.0	0.0	0.0	0.0
17. QUINCY, ILL.	350.5	47500.	0.63E+00	0.38E+00	0.51E+00	0.13E+00
18. HANNIBAL, MO.	368.5	21000.	0.26E+00	0.15E+00	0.22E+00	0.54E-01
19. LOCK AND DAM 24	403.5	0.	0.0	0.0	0.0	0.0
20. LOCK AND DAM 25	436.0	0.	0.0	0.0	0.0	0.0
21. LOCK AND DAM 26	474.5	0.	0.0	0.0	0.0	0.0
22. LOCK AND DAM 27	492.2	40073.	0.24E+00	0.95E-01	0.19E+00	0.47E-01
23. ST.LOUIS,E.ST.LOUIS	497.5	570015.	0.35E+01	0.14E+01	0.29E+01	0.71E+00
24. CHESTER, ILL.	568.0	4200.	0.22E-01	0.80E-02	0.18E-01	0.43E-02

25. CAPE GIRARDEAU, MO.	625.5	25700.	0.13E+00	0.44E-01	0.11E+00	0.26E-01
26. THEBES, ILL.	633.5	450.	0.23E-02	0.77E-03	0.19E-02	0.45E-03
27. VICKSBURG, MISS.	1195.3	41000.	0.66E-01	0.12E-01	0.54E-01	0.13E-01
28. DONALDSVILLE, LA.	1456.3	7750.	0.12E-01	0.19E-02	0.10E-01	0.23E-02
29. NEW ORLEANS, LA.	1533.3	652125.	0.10E+01	0.14E+00	0.85E+00	0.19E+00
TOTALS		1773909.	0.11E+02	0.73E+01	0.87E+01	0.22E+01

Genoa: Drinking water doses by location
(continued)

Genoa: Commercial fish ingestion doses by location

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. GENOA	0.0	0.	0.0	0.0	0.0	0.0
2. LOCK AND DAM 8	0.3	1112264.	0.16E+01	0.30E+00	0.13E+01	0.74E-01
3. LOCK AND DAM 9	29.5	2040780.	0.27E+01	0.34E+00	0.22E+01	0.12E+00
4. LOCK AND DAM 10	62.3	675405.	0.80E+00	0.79E-01	0.66E+00	0.36E-01
5. LOCK AND DAM 11	94.5	528808.	0.55E+00	0.43E-01	0.46E+00	0.25E-01
6. LOCK AND DAM 12	122.8	405587.	0.37E+00	0.25E-01	0.30E+00	0.17E-01
7. LOCK AND DAM 13	155.0	884603.	0.76E+00	0.42E-01	0.64E+00	0.34E-01
8. LOCK AND DAM 14	184.2	396522.	0.32E+00	0.16E-01	0.27E+00	0.14E-01
9. BETTENDORF-MOLINE	191.5	151214.	0.12E+00	0.57E-02	0.10E+00	0.54E-02
10. DAVENPORT-ROCKISLAND	194.5	458510.	0.36E+00	0.16E-01	0.30E+00	0.16E-01
11. LOCK AND DAM 17	240.3	450113.	0.33E+00	0.13E-01	0.27E+00	0.13E-01
12. LOCK AND DAM 18	267.0	928499.	0.65E+00	0.22E-01	0.54E+00	0.29E-01
13. BURLINGTON, IOWA	273.3	0.	0.0	0.0	0.0	0.0
14. FT. MADISON	295.0	0.	0.0	0.0	0.0	0.0
15. KEOKUK, L&D 19	313.5	920778.	0.59E+00	0.16E-01	0.50E+00	0.26E-01
16. LOCK AND DAM 20	334.3	75557.	0.46E-01	0.11E-02	0.38E-01	0.20E-02
17. QUINCY, ILL.	350.5	138218.	0.79E-01	0.18E-02	0.66E-01	0.35E-02
18. HANNIBAL, MO.	369.5	128689.	0.70E-01	0.15E-02	0.58E-01	0.31E-02
19. LOCK AND DAM 24	403.5	214530.	0.11E+00	0.20E-02	0.88E-01	0.46E-02
20. LOCK AND DAM 25	436.0	336105.	0.15E+00	0.27E-02	0.13E+00	0.67E-02
21. LOCK AND DAM 26	474.5	353487.	0.15E+00	0.23E-02	0.12E+00	0.64E-02
22. LOCK AND DAM 27	492.2	264390.	0.67E-01	0.10E-02	0.56E-01	0.29E-02
23. ST.LOUIS,E.ST.LOUIS	497.5	0.	0.0	0.0	0.0	0.0

24. CHESTER, ILL.	568.0	0.	0.0	0.0	0.0	0.0
25. CAPE GIRARDEAU, MO.	625.5	0.	0.0	0.0	0.0	0.0
26. THEBES, ILL.	633.5	0.	0.0	0.0	0.0	0.0
27. VICKSBURG, MISS.	1195.3	0.	0.0	0.0	0.0	0.0
28. DONALDSVILLE, LA.	1456.3	0.	0.0	0.0	0.0	0.0
29. NEW ORLEANS, LA.	1533.3	0.	0.0	0.0	0.0	0.0
TOTALS		10464149.	0.99E+01	0.93E+00	0.82E+01	0.44E+00

Genoa: Commercial fish ingestion doses by location
(continued)

Genoa: Creel fish ingestion doses by location

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. GENOA	0.0	111.	0.33E-01	0.80E-02	0.28E-01	0.16E-02
2. LOCK AND DAM 8	0.3	0.	0.0	0.0	0.0	0.0
3. LOCK AND DAM 9	29.5	0.	0.0	0.0	0.0	0.0
4. LOCK AND DAM 10	62.3	0.	0.0	0.0	0.0	0.0
5. LOCK AND DAM 11	94.5	142927.	0.31E+00	0.24E-01	0.25E+00	0.14E-01
6. LOCK AND DAM 12	122.8	0.	0.0	0.0	0.0	0.0
7. LOCK AND DAM 13	155.0	118932.	0.21E+00	0.12E-01	0.17E+00	0.94E-02
8. LOCK AND DAM 14	184.2	0.	0.0	0.0	0.0	0.0
9. BETTENDORF-MOLINE	191.5	0.	0.0	0.0	0.0	0.0
10. DAVENPORT-ROCKISLAND	194.5	0.	0.0	0.0	0.0	0.0
11. LOCK AND DAM 17	240.3	0.	0.0	0.0	0.0	0.0
12. LOCK AND DAM 18	267.0	83669.	0.12E+00	0.40E-02	0.99E-01	0.53E-02
13. BURLINGTON, IOWA	273.3	0.	0.0	0.0	0.0	0.0
14. FT. MADISON	295.0	0.	0.0	0.0	0.0	0.0
15. KEOKUK, L&D 19	313.5	0.	0.0	0.0	0.0	0.0
16. LOCK AND DAM 20	334.3	0.	0.0	0.0	0.0	0.0
17. QUINCY, ILL.	350.5	0.	0.0	0.0	0.0	0.0
18. HANNIBAL, MO.	369.5	0.	0.0	0.0	0.0	0.0
19. LOCK AND DAM 24	403.5	0.	0.0	0.0	0.0	0.0
20. LOCK AND DAM 25	436.0	0.	0.0	0.0	0.0	0.0
21. LOCK AND DAM 26	474.5	38761.	0.33E-01	0.52E-03	0.27E-01	0.14E-02
22. LOCK AND DAM 27	492.2	0.	0.0	0.0	0.0	0.0
23. ST.LOUIS,E.ST.LOUIS	497.5	0.	0.0	0.0	0.0	0.0

24. CHESTER, ILL.	559.0	0.	0.0	0.0	0.0	0.0
25. CAPE GIRARDEAU, MO.	625.5	0.	0.0	0.0	0.0	0.0
26. THEBES, ILL.	633.5	0.	0.0	0.0	0.0	0.0
27. VICKSBURG, MISS.	1195.3	0.	0.0	0.0	0.0	0.0
28. DONALDSVILLE, LA.	1456.3	0.	0.0	0.0	0.0	0.0
29. NEW ORLEANS, LA.	1533.3	0.	0.0	0.0	0.0	0.0
TOTALS		384400.	0.70E+00	0.49E-01	0.59E+00	0.32E-01

Genoa: Creel fish ingestion doses by location
(continued)

	TRAVEL TIME TO DOWNSTREAM POINTS (HRS.)
1. GENOA	0.0
2. LOCK AND DAM 8	0.2
3. LOCK AND DAM 9	15.5
4. LOCK AND DAM 10	32.8
5. LOCK AND DAM 11	49.7
6. LOCK AND DAM 12	64.6
7. LOCK AND DAM 13	81.6
8. LOCK AND DAM 14	96.9
9. BETTENDORF-MOLINE	100.8
10. DAVENPORT-ROCKISLAND	102.4
11. LOCK AND DAM 17	126.5
12. LOCK AND DAM 18	140.5
13. BURLINGTON, IOWA	143.8
14. FT. MADISON	155.3
15. KEOKUK, L&D 19	165.0
16. LOCK AND DAM 20	175.9
17. QUINCY, ILL.	184.5
18. HANNIBAL, MO.	193.9
19. LOCK AND DAM 24	212.4
20. LOCK AND DAM 25	229.5
21. LOCK AND DAM 26	249.7
22. LOCK AND DAM 27	259.1
23. ST.LOUIS,E.ST.LOUIS	261.8
24. CHESTER, ILL.	286.2
25. CAPE GIRARDEAU, MO.	306.0
26. THEBES, ILL.	309.7
27. VICKSBURG, MISS.	482.1
28. DONALDSVILLE, LA.	562.7
29. NEW ORLEANS, LA.	586.5

Genoa: Travel time to downstream locations

Quad Cities: Input data

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
QUAD CITIES	1973	12	

LOCATIONS ON STREAM (TOTAL OF 23, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	QUAD CITIES	1.	1915.	1.9	-1458.8	0.	0.	111.
2	LOCK AND DAM 14	0.	49660.	1.9	-1449.1	80000.	396522.	0.
3	BETTENDORF-MOLINE	55555.	50363.	1.9	-1441.8	30000.	151214.	0.
4	DAVENPORT-ROCKISLAND	141580.	50652.	1.9	-1438.8	89400.	458510.	0.
5	LOCK AND DAM 17	0.	55065.	1.9	-1393.0	51400.	450113.	0.
6	LOCK AND DAM 18	0.	57638.	1.9	-1366.3	95800.	928489.	83669.
7	BURLINGTON, IOWA	35400.	58245.	1.9	-1360.0	0.	0.	0.
8	FT. MADISON	15245.	60336.	1.9	-1338.3	0.	0.	0.
9	KEOKUK, LOD 19	16315.	62119.	1.9	-1319.8	214000.	920778.	0.
10	LOCK AND DAM 20	0.	66636.	1.9	-1299.0	73600.	75657.	0.
11	QUINCY, ILL.	47500.	70155.	1.9	-1282.8	76400.	138218.	0.
12	HANNIBAL, MO.	21000.	74065.	1.9	-1264.8	91000.	128689.	0.
13	LOCK AND DAM 24	0.	81776.	1.9	-1229.8	29745.	214530.	0.
14	LOCK AND DAM 25	0.	88727.	1.9	-1197.3	49674.	336105.	0.
15	LOCK AND DAM 26	0.	97090.	1.9	-1158.8	107082.	353487.	38761.
16	LOCK AND DAM 27	40073.	157739.	1.9	-1141.1	0.	264390.	0.
17	ST.LOUIS,E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
18	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
19	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
20	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
21	VICKSBURG, MISS.	41000.	574000.	3.2	-438.0	0.	0.	0.
22	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
23	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 20)

	DOSE CONVERSION FACTORS	
	INGESTION	SWIMMING

ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE BODY	THYROID	BONE	GI-LLI	MREM/HR PER PCI/LITER SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.71CE-02	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-06	0.970E+00	0.168E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05
CO-60	0	0.	27	0.418E-08	0.830E+00	0.47CE-05	0.0	0.0	0.394E-04	0.540E-05	0.460E-05
CR-51	0	0.	24	0.289E-06	0.288E+01	0.267E-08	0.159E-08	0.0	0.669E-06	0.640E-07	0.520E-07
CS-134	0	0.	55	0.1C7E-07	0.210E+00	0.10CE-03	0.0	0.529E-04	0.256E-05	0.350E-05	0.290E-05
CS-137	0	0.	55	0.733E-09	0.530E+00	0.560E-04	0.0	0.637E-04	0.205E-05	0.140E-05	0.100E-05
BA-137M	1	100.	56	0.163E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3	0	0.	1	0.179E-08	0.245E+02	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.380E+01	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06
XE-131M	1	1.	54	0.68CE-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
I-133	0	0.	53	0.916E-05	0.430E+00	0.702E-06	0.482E-03	0.143E-05	0.225E-05	0.150E-05	0.960E-06
XE-133	1	100.	54	0.152E-05	0.0	0.0	0.0	0.0	0.0	0.110E-06	0.570E-07
MN-54	0	0.	25	0.269E-07	0.370E+00	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.640E-01	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.250E-02	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07
ZN-65	0	0.	30	0.32EE-07	0.850E-01	0.508E-05	0.0	0.346E-05	0.978E-05	0.120E-05	0.110E-05
ZR-95	0	0.	40	0.122E-06	0.116E+00	0.634E-08	0.0	0.270E-07	0.229E-04	0.180E-05	0.150E-05
NB-95	1	100.	41	0.229E-06	0.0	0.181E-08	0.0	0.556E-08	0.203E-04	0.160E-05	0.140E-05

Quad Cities: Input data
(continued)

Quad Cities: Drinking water doses by location

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. QUAD CITIES	0.0	1.	0.32E-04	0.30E-02	0.34E-04	0.30E-04
2. LOCK AND DAM 14	9.7	0.	0.0	0.0	0.0	0.0
3. BETTENDORF-MOLINE	17.0	55555.	0.65E-01	0.56E+01	0.70E-01	0.62E-01
4. DAVENPORT-ROCKISLAND	20.0	141580.	0.16E+00	0.13E+02	0.17E+00	0.15E+00
5. LOCK AND DAM 17	65.8	0.	0.0	0.0	0.0	0.0
6. LOCK AND DAM 18	92.5	0.	0.0	0.0	0.0	0.0
7. BURLINGTON, IOWA	98.8	35400.	0.34E-01	0.22E+01	0.36E-01	0.33E-01
8. FT. MADISON	120.5	15245.	0.14E-01	0.86E+00	0.15E-01	0.14E-01
9. KEOKUK, LOD 19	139.0	16315.	0.14E-01	0.75E+00	0.15E-01	0.14E-01
10. LOCK AND DAM 20	159.8	0.	0.0	0.0	0.0	0.0
11. QUINCY, ILL.	176.0	47500.	0.37E-01	0.16E+01	0.38E-01	0.35E-01
12. HANNIBAL, MO.	194.0	21000.	0.15E-01	0.63E+00	0.16E-01	0.15E-01
13. LOCK AND DAM 24	229.0	0.	0.0	0.0	0.0	0.0
14. LOCK AND DAM 25	261.5	0.	0.0	0.0	0.0	0.0
15. LOCK AND DAM 26	300.0	0.	0.0	0.0	0.0	0.0
16. LOCK AND DAM 27	317.7	40073.	0.13E-01	0.41E+00	0.14E-01	0.13E-01
17. ST.LOUIS,E.ST.LOUIS	323.0	670015.	0.20E+00	0.61E+01	0.20E+00	0.19E+00
18. CHESTER, ILL.	393.5	4200.	0.12E-02	0.34E-01	0.12E-02	0.12E-02
19. CAPE GIRARDEAU, MO.	451.0	25700.	0.72E-02	0.19E+00	0.73E-02	0.69E-02
20. THEBES, ILL.	459.0	450.	0.13E-03	0.33E-02	0.13E-03	0.12E-03
21. VICKSBURG, MISS.	1020.8	41000.	0.36E-02	0.52E-01	0.36E-02	0.34E-02
22. DONALDSVILLE, LA.	1281.8	7150.	0.67E-03	0.73E-02	0.65E-03	0.64E-03
23. NEW ORLEANS, LA.	1358.8	652125.	0.56E-01	0.57E+00	0.55E-01	0.53E-01
TOTALS		1773909.	0.63E+00	0.32E+02	0.65E+00	0.60E+00

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. QUAD CITIES	0.0	0.	0.0	0.0	0.0	0.0
2. LOCK AND DAM 14	9.7	396522.	0.15E-01	0.71E-01	0.13E-01	0.32E-02
3. BETTENDORF-MOLINE	17.0	151214.	0.56E-02	0.25E-01	0.50E-02	0.14E-02
4. DAVENPORT-ROCKISLAND	20.0	458510.	0.17E-01	0.70E-01	0.15E-01	0.51E-02
5. LOCK AND DAM 17	65.8	450113.	0.15E-01	0.56E-01	0.14E-01	0.60E-02
6. LOCK AND DAM 18	92.5	528489.	0.30E-01	0.97E-01	0.27E-01	0.14E-01
7. BURLINGTON, IOWA	98.8	0.	0.0	0.0	0.0	0.0
8. FT. MADISON	120.5	0.	0.0	0.0	0.0	0.0
9. KEOKUK, LOD 19	139.0	520778.	0.28E-01	0.71E-01	0.24E-01	0.17E-01
10. LOCK AND DAM 20	159.8	75657.	0.21E-02	0.50E-02	0.19E-02	0.14E-02
11. QUINCY, ILL.	176.0	138218.	0.37E-02	0.81E-02	0.32E-02	0.26E-02
12. HANNIBAL, MO.	194.0	128689.	0.32E-02	0.65E-02	0.29E-02	0.25E-02
13. LOCK AND DAM 24	229.0	214530.	0.49E-02	0.91E-02	0.43E-02	0.40E-02
14. LOCK AND DAM 25	261.5	336105.	0.70E-02	0.12E-01	0.62E-02	0.60E-02
15. LOCK AND DAM 26	300.0	353487.	0.68E-02	0.10E-01	0.60E-02	0.62E-02
16. LOCK AND DAM 27	317.7	264390.	0.31E-02	0.46E-02	0.27E-02	0.29E-02
17. ST.LOUIS,E.ST.LOUIS	323.0	0.	0.0	0.0	0.0	0.0
18. CHESTER, ILL.	393.5	0.	0.0	0.0	0.0	0.0
19. CAPE GIRARDEAU, MO.	451.0	0.	0.0	0.0	0.0	0.0
20. THEBES, ILL.	459.0	0.	0.0	0.0	0.0	0.0
21. VICKSBURG, MISS.	1020.8	0.	0.0	0.0	0.0	0.0
22. DONALDSVILLE, LA.	1281.8	0.	0.0	0.0	0.0	0.0
23. NEW ORLEANS, LA.	1358.8	0.	0.0	0.0	0.0	0.0
TOTALS		4816702.	0.14E+00	0.45E+00	0.12E+00	0.73E-01

Quad Cities: Commercial fish ingestion doses by location

Quad Cities: Creel fish ingestion doses by location

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. QUAD CITIES	0.0	111.	0.22E-03	0.12E-02	0.20E-03	0.33E-04
2. LOCK AND DAM 14	9.7	0.	0.0	0.0	0.0	0.0
3. BETTENDORF-MOLINE	17.0	0.	0.0	0.0	0.0	0.0
4. DAVENPORT-ROCKISLAND	20.0	0.	0.0	0.0	0.0	0.0
5. LOCK AND DAM 17	65.8	0.	0.0	0.0	0.0	0.0
6. LOCK AND DAM 18	92.5	83665.	0.56E-02	0.18E-01	0.49E-02	0.26E-02
7. BURLINGTON, IOWA	98.8	0.	0.0	0.0	0.0	0.0
8. FT. MADISON	120.5	0.	0.0	0.0	0.0	0.0
9. KEOKUK, LCD 19	139.0	0.	0.0	0.0	0.0	0.0
10. LOCK AND DAM 20	159.8	0.	0.0	0.0	0.0	0.0
11. QUINCY, ILL.	176.0	0.	0.0	0.0	0.0	0.0
12. HANNIBAL, MO.	194.0	0.	0.0	0.0	0.0	0.0
13. LOCK AND DAM 24	229.0	0.	0.0	0.0	0.0	0.0
14. LOCK AND DAM 25	261.5	0.	0.0	0.0	0.0	0.0
15. LOCK AND DAM 26	300.0	38761.	0.15E-02	0.23E-02	0.13E-02	0.14E-02
16. LOCK AND DAM 27	317.7	0.	0.0	0.0	0.0	0.0
17. ST.LOUIS,E.ST.LOUIS	323.0	0.	0.0	0.0	0.0	0.0
18. CHESTER, ILL.	393.5	0.	0.0	0.0	0.0	0.0
19. CAPE GIRARDEAU, MO.	451.0	0.	0.0	0.0	0.0	0.0
20. THEBES, ILL.	459.0	0.	0.0	0.0	0.0	0.0
21. VICKSBURG, MISS.	1020.8	0.	0.0	0.0	0.0	0.0
22. DONALDSVILLE, LA.	1281.8	0.	0.0	0.0	0.0	0.0
23. NEW ORLEANS, LA.	1358.8	0.	0.0	0.0	0.0	0.0
TOTALS		122541.	0.73E-02	0.21E-01	0.64E-02	0.40E-02

PROGRAM RVRDOS

FOR INFORMATION REGARDING THIS PROGRAM, CONTACT:

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
401 M ST SW
WASHINGTON, DC 20460

INPUT DATA

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
DRESDEN UNITS 2/3	1973	12	

LOCATIONS ON STREAM (TOTAL OF 13, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	DRESDEN	1.	1690.	1.2	-1445.7	0.	0.	111.
2	MARSEILLES LOCK,DAM	0.	10750.	2.5	-1421.3	18009.	0.	0.
3	STARVED ROCK L&D	0.	11280.	1.6	-1404.3	11344.	0.	0.
4	PEORIA LOCK AND DAM	0.	13740.	0.9	-1331.0	49630.	26204.	0.
5	LAGRANGE LOCK,DAM	0.	19980.	0.9	-1253.5	57297.	143104.	0.
6	ALTON, MO.	0.	97090.	1.2	-1159.9	0.	231463.	0.
7	ST.LOUIS, E.ST.LOUIS	670015.	175900.	1.9	-1135.9	0.	0.	0.
8	CHESTER, ILL.	4200.	180600.	2.9	-1055.3	0.	0.	0.
9	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
10	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
11	VICKSBURG, MISS.	41000.	574000.	3.2	-438.0	0.	0.	0.
12	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
13	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 18)

ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	DOSE CONVERSION FACTORS INGESTION MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE BODY	THYROID	BONE	GI-LLI	SWIMMING MREM/HR PER PCI/LITER SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.148E+01	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-05	0.144E+00	0.158E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05

Dresden 2/3: Input data

Dresden 2/3: Input data (continued)

CO-60	C	0.	27	0.418E-08	0.209E+01	0.470E-05	0.0	0.0	0.394E-04	0.540E-05	0.460E-05
CR-51	C	0.	24	0.289E-06	0.117E+01	0.267E-08	0.159E-09	0.0	0.569E-06	0.640E-07	0.520E-07
CS-134	C	0.	55	0.107E-07	0.117E+01	0.100E-03	0.0	0.529E-04	0.256E-05	0.350E-05	0.290E-05
CS-137	C	0.	55	0.733E-09	0.424E+01	0.560E-04	0.0	0.637E-04	0.205E-05	0.140E-05	0.100E-05
BA-137M	1	100.	55	0.163E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3	C	0.	1	0.179E-08	0.259E+02	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.141E+01	0.337E-05	0.185E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06
XE-131M	1	1.	54	0.698E-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
MN-54	0	0.	25	0.265E-07	0.406E+00	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-05	0.890E-01	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.100E-01	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-05	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07
ZN-65	C	0.	30	0.328E-07	0.370E-01	0.508E-05	0.0	0.346E-05	0.978E-05	0.120E-05	0.110E-05
ZR-95	0	0.	40	0.122E-05	0.900E-02	0.534E-08	0.0	0.270E-07	0.223E-04	0.180E-05	0.150E-05
NB-95	1	100.	41	0.229E-06	0.700E-02	0.181E-08	0.0	0.556E-09	0.203E-04	0.160E-05	0.140E-05

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. DRESDEN	0.0	1.	0.18E-03	0.12E-02	0.19E-03	0.81E-04
2. MARSEILLES LOCK,DAM	25.4	0.	0.0	0.0	0.0	0.0
3. STARVED ROCK L&D	41.4	0.	0.0	0.0	0.0	0.0
4. PEORIA LOCK AND DAM	114.7	0.	0.0	0.0	0.0	0.0
5. LAGRANGE LOCK,DAM	192.2	0.	0.0	0.0	0.0	0.0
6. ALTON, MO.	286.9	0.	0.0	0.0	0.0	0.0
7. ST.LOUIS, E.ST.LOUIS	309.9	670015.	0.11E+01	0.20E+01	0.11E+01	0.33E+00
8. CHESTER, ILL.	380.4	4200.	0.70E-02	0.11E-01	0.66E-02	0.20E-02
9. CAPE GIRARDEAU, MO.	437.9	25700.	0.42E-01	0.64E-01	0.40E-01	0.12E-01
10. THEBES, ILL.	445.9	450.	0.73E-03	0.11E-02	0.69E-03	0.21E-03
11. VICKSBURG, MISS.	1007.7	41000.	0.21E-01	0.17E-01	0.20E-01	0.62E-02
12. DONALDSVILLE, LA.	1268.7	7750.	0.40E-02	0.25E-02	0.38E-02	0.12E-02
13. NEW ORLEANS, LA.	1345.7	652125.	0.34E+00	0.19E+00	0.32E+00	0.97E-01
TOTALS		1401241.	0.16E+01	0.23E+01	0.15E+01	0.45E+00

Dresden 2/3: Drinking water doses by location

Dresden 2/3: Commercial fish ingestion doses by location

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMPTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

	LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1.	DRESDEN	0.0	0.	0.0	0.0	0.0	0.0
2.	MARSEILLES LOCK,DAM	25.4	0.	0.0	0.0	0.0	0.0
3.	STARVED ROCK LGD	41.4	0.	0.0	0.0	0.0	0.0
4.	PEORIA LOCK AND DAM	114.7	26204.	0.24E-01	0.35E-02	0.23E-01	0.20E-02
5.	LAGRANGE LOCK,DAM	192.2	143104.	0.91E-01	0.89E-02	0.86E-01	0.76E-02
6.	ALTON, MO.	286.9	231463.	0.30E-01	0.22E-02	0.28E-01	0.25E-02
7.	ST.LOUIS, E.ST.LOUIS	309.9	0.	0.0	0.0	0.0	0.0
8.	CHESTER, ILL.	380.4	0.	0.0	0.0	0.0	0.0
9.	CAPE GIRARDEAU, MO.	437.9	0.	0.0	0.0	0.0	0.0
10.	THEBES, ILL.	445.9	0.	0.0	0.0	0.0	0.0
11.	VICKSBURG, MISS.	1007.7	0.	0.0	0.0	0.0	0.0
12.	DONALDSVILLE, LA.	1268.7	0.	0.0	0.0	0.0	0.0
13.	NEW ORLEANS, LA.	1345.7	0.	0.0	0.0	0.0	0.0
	TOTALS		400771.	0.15E+00	0.15E-01	0.14E+00	0.12E-01

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. DRESDEN	0.0	111.	0.17E-02	0.47E-03	0.16E-02	0.14E-03
2. MARSEILLES LOCK,DAM	25.4	0.	0.0	0.0	0.0	0.0
3. STARVED ROCK L&D	41.4	0.	0.0	0.0	0.0	0.0
4. PEORIA LOCK AND DAM	114.7	0.	0.0	0.0	0.0	0.0
5. LAGRANGE LOCK,DAM	192.2	0.	0.0	0.0	0.0	0.0
6. ALTON, MO.	286.9	0.	0.0	0.0	0.0	0.0
7. ST.LOUIS, E.ST.LOUIS	309.9	0.	0.0	0.0	0.0	0.0
8. CHESTER, ILL.	380.4	0.	0.0	0.0	0.0	0.0
9. CAPE GIRARDEAU, MO.	437.9	0.	0.0	0.0	0.0	0.0
10. THEBES, ILL.	445.9	0.	0.0	0.0	0.0	0.0
11. VICKSBURG, MISS.	1007.7	0.	0.0	0.0	0.0	0.0
12. DONALDSVILLE, LA.	1268.7	0.	0.0	0.0	0.0	0.0
13. NEW ORLEANS, LA.	1345.7	0.	0.0	0.0	0.0	0.0
TOTALS		111.	0.17E-02	0.47E-03	0.16E-02	0.14E-03

Dresden 2/3: Creel fish ingestion doses by location

Fort Calhoun: Input data

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
FORT CALHOUN	1973	12	

LOCATIONS ON STREAM (TOTAL OF 18, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	FORT CALHOUN	1.	242.	2.6	-1795.0	0.	0.	111.
2	OMAHA, NEB.	303305.	26750.	2.6	-1776.0	0.	0.	0.
3	COUNCIL BLUFFS, IOWA	56000.	26950.	2.6	-1775.0	0.	0.	0.
4	PLATTSMOUTH, NEB.	0.	30360.	3.3	-1740.1	0.	29752.	0.
5	ST. JOSEPH, MO.	92000.	38340.	2.9	-1597.6	0.	0.	0.
6	ATCHISON, KAN.	15000.	43360.	2.6	-1571.6	0.	0.	0.
7	LEAVENWORTH, KAN.	23600.	48460.	2.7	-1546.1	0.	0.	0.
8	KANSAS CITY, KAN, MO	825000.	54580.	3.4	-1514.1	0.	49815.	0.
9	LEXINGTON, MO.	4900.	55330.	3.0	-1466.4	0.	0.	0.
10	JEFFERSON CITY, MO.	31500.	68950.	2.9	-1293.0	0.	0.	0.
11	GRANITE CITY, ILL.	43000.	158900.	2.6	-1139.8	0.	335022.	0.
12	ST.LOUIS, E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
13	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
14	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
15	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
16	VICKSBURG, MISS.	41000.	574000.	3.2	-439.0	0.	0.	0.
17	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
18	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 11)

ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	DOSE CONVERSION FACTORS INGESTION MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE BODY	THYROID	BONE	GI-LLI	SWIMMING MREM/HR PER PCI/LITER SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.607E-01	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-59	0	0.	27	0.113E-06	0.469E-04	0.169E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05
H-3	0	0.	1	0.179E-08	0.159E+02	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.448E-02	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06

XE-131M	1	1.	54	0.680E-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
XE-133	1	100.	54	0.152E-05	0.580E-01	0.0	0.0	0.0	0.0	0.110E-06	0.570E-07
MN-54	0	0.	25	0.265E-07	0.219E+00	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.116E-03	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.169E-04	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07

Fort Calhoun: Input data
(continued)

Fort Calhoun: Drinking water doses by location

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. FORT CALHOUN	0.0	1.	0.76E-05	0.34E-04	0.42E-05	0.21E-04
2. OMAHA, NEB.	19.0	303305.	0.21E-01	0.92E-01	0.70E-02	0.49E-01
3. COUNCIL BLUFFS, IOWA	19.0	56000.	0.38E-02	0.17E-01	0.13E-02	0.90E-02
4. PLATTSMOUTH, NEB.	54.9	0.	0.0	0.0	0.0	0.0
5. ST. JOSEPH, MO.	197.4	92000.	0.42E-02	0.16E-01	0.12E-03	0.77E-02
6. ATCHISON, KAN.	223.4	15000.	0.61E-03	0.23E-02	0.16E-04	0.11E-02
7. LEAVENWORTH, KAN.	248.9	23600.	0.86E-03	0.31E-02	0.22E-04	0.16E-02
8. KANSAS CITY, KAN, MO	280.9	925000.	0.27E-01	0.95E-01	0.65E-03	0.48E-01
9. LEXINGTON, MO.	328.6	4900.	0.16E-03	0.53E-03	0.37E-05	0.28E-03
10. JEFFERSON CITY, MO.	502.0	31500.	0.81E-03	0.24E-02	0.18E-04	0.15E-02
11. GRANITE CITY, ILL.	555.2	43000.	0.48E-03	0.12E-02	0.99E-05	0.86E-03
12. ST.LOUIS, E.ST.LOUIS	659.2	670015.	0.67E-02	0.17E-01	0.14E-03	0.12E-01
13. CHESTER, ILL.	729.7	4200.	0.41E-04	0.98E-04	0.83E-06	0.74E-04
14. CAPE GIRARDEAU, MO.	787.2	25700.	0.24E-03	0.56E-03	0.49E-05	0.44E-03
15. THEBES, ILL.	795.2	450.	0.43E-05	0.98E-05	0.85E-07	0.77E-05
16. VICKSBURG, MISS.	1357.0	41000.	0.13E-03	0.21E-03	0.22E-05	0.22E-03
17. DONALDSVILLE, LA.	1619.0	7750.	0.23E-04	0.34E-04	0.38E-06	0.41E-04
18. NEW ORLEANS, LA.	1695.0	652125.	0.20E-02	0.29E-02	0.32E-04	0.35E-02
TOTALS		2795546.	0.67E-01	0.25E+00	0.93E-02	0.14E+00

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 90 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. FORT CALHOUN	0.0	0.	0.0	0.0	0.0	0.0
2. OMAHA, NEB.	19.0	0.	0.0	0.0	0.0	0.0
3. COUNCIL BLUFFS, IOWA	19.0	0.	0.0	0.0	0.0	0.0
4. PLATTSMOUTH, NEB.	54.9	29752.	0.19E-05	0.10E-04	0.15E-06	0.27E-04
5. ST. JOSEPH, MO.	197.4	0.	0.0	0.0	0.0	0.0
6. ATCHISON, KAN.	223.4	0.	0.0	0.0	0.0	0.0
7. LEAVENWORTH, KAN.	248.9	0.	0.0	0.0	0.0	0.0
8. KANSAS CITY, KAN, MO	280.9	48815.	0.17E-05	0.72E-05	0.32E-07	0.24E-04
9. LEXINGTON, MO.	328.6	0.	0.0	0.0	0.0	0.0
10. JEFFERSON CITY, MO.	502.0	0.	0.0	0.0	0.0	0.0
11. GRANITE CITY, ILL.	655.2	335022.	0.39E-05	0.11E-04	0.59E-07	0.56E-04
12. ST.LOUIS, E.ST.LOUIS	659.2	0.	0.0	0.0	0.0	0.0
13. CHESTER, ILL.	729.7	0.	0.0	0.0	0.0	0.0
14. CAPE GIRARDEAU, MO.	787.2	0.	0.0	0.0	0.0	0.0
15. THEBES, ILL.	795.2	0.	0.0	0.0	0.0	0.0
16. VICKSBURG, MISS.	1357.0	0.	0.0	0.0	0.0	0.0
17. DONALDSVILLE, LA.	1618.0	0.	0.0	0.0	0.0	0.0
18. NEW ORLEANS, LA.	1695.0	0.	0.0	0.0	0.0	0.0
TOTALS		413589.	0.74E-05	0.29E-04	0.24E-06	0.11E-03

Fort Calhoun: Commercial fish ingestion doses by location

Fort Calhoun: Creel fish ingestion doses by location

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. FORT CALHOUN	0.0	111.	0.18E-05	0.11E-04	0.45E-06	0.26E-04
2. OMAHA, NEB.	19.0	0.	0.0	0.0	0.0	0.0
3. COUNCIL BLUFFS, IOWA	19.0	0.	0.0	0.0	0.0	0.0
4. PLATTSMOUTH, NEB.	54.7	0.	0.0	0.0	0.0	0.0
5. ST. JOSEPH, MO.	197.4	0.	0.0	0.0	0.0	0.0
6. ATCHISON, KAN.	223.4	0.	0.0	0.0	0.0	0.0
7. LEAVENWORTH, KAN.	249.7	0.	0.0	0.0	0.0	0.0
8. KANSAS CITY, KAN, MO	280.9	0.	0.0	0.0	0.0	0.0
9. LEXINGTON, MO.	329.6	0.	0.0	0.0	0.0	0.0
10. JEFFERSON CITY, MO.	502.0	0.	0.0	0.0	0.0	0.0
11. GRANITE CITY, ILL.	655.2	0.	0.0	0.0	0.0	0.0
12. ST.LOUIS, E.ST.LOUIS	659.2	0.	0.0	0.0	0.0	0.0
13. CHESTER, ILL.	729.7	0.	0.0	0.0	0.0	0.0
14. CAPE GIRARDEAU, MO.	787.2	0.	0.0	0.0	0.0	0.0
15. THEBES, ILL.	795.2	0.	0.0	0.0	0.0	0.0
16. VICKSBURG, MISS.	1357.0	0.	0.0	0.0	0.0	0.0
17. DONALDSVILLE, LA.	1618.0	0.	0.0	0.0	0.0	0.0
18. NEW ORLEANS, LA.	1695.0	0.	0.0	0.0	0.0	0.0
TOTALS		111.	0.18E-05	0.11E-04	0.45E-06	0.26E-04